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THE SEQUOIAS OF THE WEST COAST.

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California, with a land area nearly three times as great as that of Illinois and a climate varying from that of Greenland in the higher snow-capped mountains to that of Southern Italy in the sunny southern counties, possesses many unusual scenic attractions and natural features of unsurpassed magnitude and grandeur. Among the greater of these are the world famous *Sequoia* and redwood trees, occurring as component parts of the State's commercial forests, but valued more highly by many on account of their size and beauty than for their economic value.

The so-called "bigtrees" of California include the two living species of the genus *Sequoia*, although the name is applied specifically and belongs most properly to the *Sequoia* of the Sierras (*Sequoia washingtonia*). This species is less abundant than the Coast redwood (*Sequoia sempervirens*) but is larger and is less exploited for lumber.

The only large redwood grove permanently reserved is in California Redwood Park near Santa Cruz, where a large number of unusually fine specimens, some of them over twenty feet in diameter and three hundred feet in height are found. These are commonly known as the "Santa Cruz bigtrees," but are the true Coast redwoods. The main redwood belt north of San Francisco Bay is entirely in private hands, and none of the trees are included in State or National reserves. The inland Sierra "bigtrees," on the other hand, are more scattered, are less accessible, and several small groups and the famous Maraposa grove are under Government protection.

The bigtree (*Sequoia washingtonia*) exists in ten isolated groves distributed along the west slope of the Sierra Nevada

Mountains from the middle fork of American River to the head of Deer Creek, a distance of about 260 miles. It occurs normally between the yellow and sugar pine, and silver-fir belts, at elevations of from 5,000 to 8,000 feet above sea level. The largest groves are in the southern part of the belt, and here also the species shows its strongest tendency toward reproduction and extension, as evidenced by the numerous saplings and small, comparatively young trees.

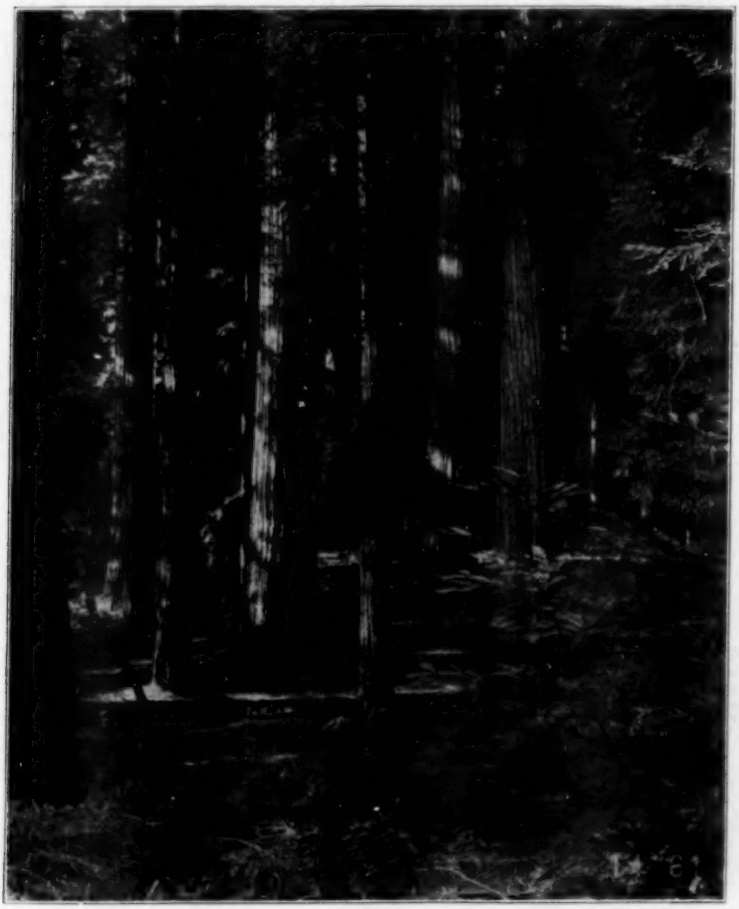
None of the groves are more than a few square miles in extent, the largest and most famous being the Tuolumne, Merced, Fresno, Mariposa, and Calaveras groves, although probably the finest is on the north fork of the Tule River. Fortunately, several of the best groves and the largest individual trees are owned wholly or in part by the Government, and are included within the General Grant, Sequoia, or Yosemite National Parks. A few small groves exist in the Sierra Forest Reserve, the Pinkey grove in Hatch Hatchy Valley being made up almost entirely of small trees (4 to 10 feet in diameter).

Most of the groves and groups are separated from one another by gaps several miles wide, there being three breaks from forty to sixty miles wide between the larger northern groves. From Kings River southward the trees are more closely associated; the broad belt of magnificent sequoias extending across the rough basins of the Kaweah and Tule are unbroken for seventy miles save by deep canyons. It is very interesting that the gaps between the *Sequoia* groves are located, in every case, i nthe basins of the vast rivers of ice, which flowed from the high mountains to the eastward during an early geologic period. The existing groves occupy the protected situations, which were not reached by these ancient glaciers.

There has been much speculation as to the former distribution of this *Sequoia* and the popular opinion is that the present groves are dwindling remnants of a much more extensive forest. It is true that the bigtree and coast redwood have come down to us from a prehistoric age, and are the only living representatives of a genus which flourished during former geologic times, twelve fossil species having been found in various parts of the globe, including the Arctic regions and parts of Europe. The investigations of John Muir, the eminent scientist and naturalist, seem however, to prove that the range of *Sequoia washingtonia* was never much more extended than at present. He finds that the

species is still in its prime, and in no danger of extinction through natural processes, even though it is but a remnant of the large genus which was forced nearly to extinction at the close of the pre-glacial period.

The existing groves of bigtrees have evidently occupied practically the same area for many thousand years, and it is im-



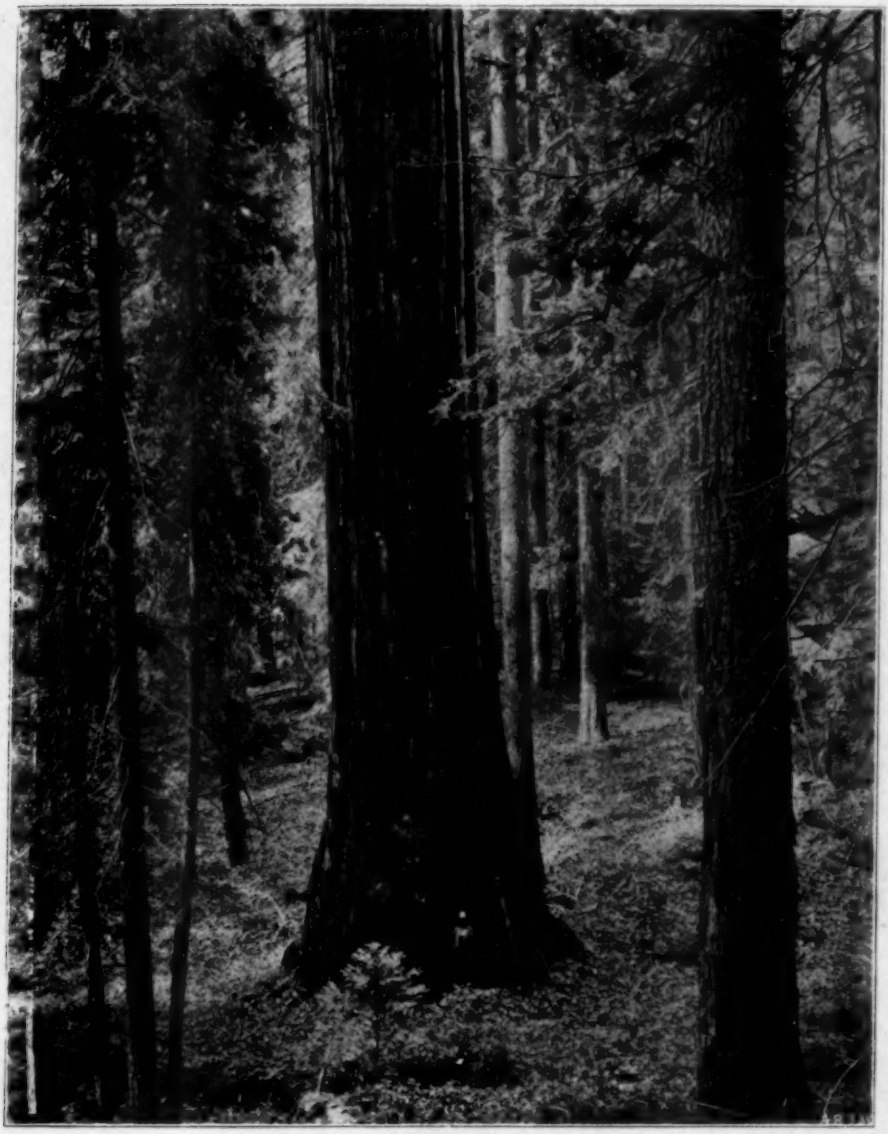
REDWOODS ON THE NORTHERN FLATS.

possible to find decaying trunks or other evidences of their existence outside of their present limits. In fact, from some of the groves volunteer young growth is pushing out into the adjacent forest. The precipitation may have decreased somewhat

since the present *Sequoia* first established itself in the Sierras, but the fact remains that the present rain and snowfall is sufficient for the luxuriant growth of *Sequoia* forests. If the fire damage could be avoided and the trees kept out of the hands of lumbermen, the forests would live indefinitely and reproduce several of their kind for every one destroyed through natural causes.

The mature trees bear seed in great abundance almost every year, but comparatively few find favorable seedbeds and germinate. The forest floor, in most places is covered with a thick litter of half-decayed needles and twigs, and it is only when this has burned off, exposing the mineral soil, that the seeds find conditions favorable for germination. This fact was taken advantage of by a forest ranger in the General Grant National Park, and several thousand seedlings, which had sprung up where piles of brush had been burned, were transplanted to open nursery beds, and will be set out later in other parts of the mountains. The species has been planted successfully for ornamental purposes in the San Joaquin Valley, and other parts of California, and it is planted quite extensively for ornament in the countries of southern and central Europe. Two specimens some 40 feet high are growing in Rochester, N. Y., but it is doubtful whether it can ever be introduced successfully in general park and roadside planting in the eastern United States.

Much has been said as to the age and size of the more famous individual bigtrees, and much unreliable information made current. Probably the largest *Sequoia* is the "General Grant" in the General Grant National Park. It has a diameter of nearly 40 feet at the base, including two prominent buttresses, and holds the distinction of being "the largest tree in the world." If these projections were excluded the diameter would be about 30 feet. The average diameter of full grown trees in favorable situations is about 20 feet, with a height of 275 feet, although trees 25 feet in diameter and 300 feet high are by no means rare. The well known Calaveras grove contains an unusually fine collection of trees, and some of the most famous. The "Mother of the Forest" is over 19 feet in diameter, without the bark, 315 feet high, and is estimated to contain 537,000 feet of sound lumber; while the "Keystone State," with a diameter of only 14 feet, is 325 feet in height. Several of the largest trees in this grove are dead and prostrate, the "Father of the Forest," with a height of nearly 400 feet when standing, probably being the tallest



A TYPICAL "BIG TREE."

Sequoia that ever grew. Another one of the larger trees was cut in 1853, and it is related on good authority that 32 people found room to dance on the 25-foot stump.

A few years ago the famous "Boole tree" on the lumber tract of the Sanger Lumber Company attracted much attention, as

it was said to have greater dimensions than any tree yet discovered. John Muir is fond of telling how he made a special trip into the mountains to measure this tree, and of his delight in finding that its girth measure exceeded any yet recorded. It turned out, however, that his companion in carrying the tape around the tree, when safely hidden by its bulk, drew up several yards of its length, and thus gave the tree an apparent circumference considerably greater than the actual.

REDWOOD LUMBERING.

Authorities differ greatly as to the age of the larger bigtrees. They are, without doubt, the oldest living individuals on the globe and their germination probaly antecedes the creation of certain species in the form they exist to-day. Writers are fond of saying that the older sequoias were in their prime when the Roman Empire fell, and were good-sized trees in the days of the early Egyptians, which is undoubtedly true. Their age, however, has often been exaggerated, as revealed by recent ring counts. The stump which was used as a dancing floor was 1,300 years old, and the age of the average tree is probably not

over 1,500 years. It is possible that some of the trees may live for 5,000 years, but the oldest tree recorded is one on which John Muir counted 4,000 annual rings of growth.

Fire and lumbering are the two forces operative against the perpetuation of these forest giants. Some of them will be preserved, but a considerable proportion of the timber is in the hands of individuals who will exercise their right of converting it into lumber. The loss in lumbering is very great as the wood is brittle and the tops unmarketable. Probably not over 25 per cent of the volume of the trees cut is converted into salable material. Fire completes the destruction of the felled trees and young growth. There is much senseless talk about the vandalism of the lumbermen, but his is a purely business proposition, and if the people want to secure the prepetuation of what are the most unique, the oldest, the largest, and the most majestically beautiful trees in the world, they should come down to business principles and secure the purchase of these bigtree groves at their market value.

The coast redwood, the companion tree to the Sierra bigtree, covers an area of about 100 times as great as that occupied by the bigtree. The commercial redwood occupies a continuous belt from ten to thirty-five miles wide along the Pacific Coast from south of the Chetco River in Oregon to southern Mendocino County in California. In addition two separate groups of commercial trees, aggregating 2,000 acres, occur north of the Chetco River, and another body is found below San Francisco Bay, in Santa Cruz County. Small isolated redwood forests of little commercial value are growing in sheltered canyons on down the coast to Punta Gorda, 500 miles from the northern limit of the species. The redwood is a moisture-loving tree, and is found only where the ocean fogs are heavy and frequent.

The redwood is primarily a commercial tree and will inevitably be cut, save where preserved in small private parks, and in the California Redwood Park. Enormous sawmills are operating in the northern belt, and lumber is being produced as fast as the market demands. The one thing which saves the tree from immediate extinction is the enormous yield per acre, which permits a high lumber output from a small area. The yield from the northern virgin redwood flats is from 125,000 to 150,000 feet per acre, board measure, lessening to 20,000 to 50,000 feet in the southern part of the belt. The annual cut of over half a

billion feet is being increased yearly. It is estimated that there are at present about seven and a half billion feet of standing redwood on 1,172,500 acres. The area already cut over is about 279,320 acres.

From an æsthetic standpoint, the redwood in some respects surpasses the bigtree. It occurs in dense, unbroken stands, and the enormous columnar trunks, rich brown bark, and dense shade broken here and there by spots of sunshine, gives an effect difficult to describe or equal. These conditions prevail only in the main northern belt, and here the trees reach their optimum development. A striking contrast exists between the trees in this region and those in Monterey County. Here, near the southern limits of the redwood's range, they possess few of the magnificent characteristics of the northern trees, but are buffeted and deformed by the winds into but a semblance of their normal grandeur. Trees no larger than bushes are often seen clinging to the lee side of the ridges with their tops flattened by the ocean gales, and only in the deep, protected cayons do they attain anything like normal size.

On the average the redwoods are taller than the bigtrees, and grow to a greater height than any other tree. The better trees are often 350 feet high, with a diameter of 20 feet, and a clear, straight trunk free of branches for 100 or more feet. Those cut for lumber are from 400 to 800 years old, and they usually decline after 500 years. The oldest redwood recorded had an age of 1,373 years.

Lumbering, accompanied as it is by fire, usually results in the utter devastation of the redwood forests. The stumps sprout freely, but the fires which follow greatly injure the sprouts, and the lumberman prefers to have the land revert to pasturage. With care, however, the cut-over redwood lands could be made to produce merchantable timber in forty to fifty years.

It is to be regretted that these unsurpassed redwood forests must disappear, and that so little will be left of them for the benefit of future generations. Here again, however, the result will depend on economic factors, and unless a philanthropic Government, or public-spirited individuals see fit to purchase portions of these redwood lands, the ax and fire will leave little to remind our descendants of these once abundant and world famous trees.

VITAL QUESTIONS FOR TEACHERS OF SECONDARY MATHEMATICS.

By J. B. Clarke,

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Before discussing in detail the special questions to be submitted for your consideration we may give at least passing attention to some general considerations which affect the whole school; but more particularly the department of mathematics, on account of the imperative demands that this subject makes upon the student's power of thought concentration.

The *sine qua non* of the successful school is a scholarly atmosphere.

The high school is not a reform school, either physical, mental, or moral. Any attempt to make it so is a fraud on the fair-minded pupils and their parents. The permitted presence of half a dozen pupils who are in school for mischief and not for study paralyzes the work of a school otherwise ideal as to environment, equipment, and *personnel*.

The high school is not a lounging place in which pupils who make a failure of their school work and whose non-success is due to conceit, obstinacy, or neglect of preparatory studies, are to be permitted to idle away their own time and by petulant complaints derange the work of the conscientious and progressive instructor.

The high school is no place for pupils so affected by what ill-advised, non-discerning parents call nervousness (but what might readily receive a more apt designation) that the discipline, mental and physical, of a class is expected to give way to the whims and caprices of the few whose perversity or lack of balance irritates and annoys the well-dispositioned members of the class quite as thoroughly as it baffles the attempts of the most skillful teacher to maintain a scholarly atmosphere.

Pupils too nervous, sensitive, or excitable to submit to necessary restraint and proper mental discipline should receive special treatment in special schools. The continued company of their own kind might have valuable therapeutic effects.

The disproportionate amount of time taken by so-called school athletics (which practically means foot-ball) militates strongly

against any attempt to secure and maintain an atmosphere of culture and scholarship. A people devoted to the apotheosis of brutality will never evolve pure, or high, ideals. What is usually termed "school athletics" is merely what is more briefly and comprehensively known in the non-academic world as "sport," with all its aftermath of gambling, juggling by flimsy protests with the actual results of field contests, wrangling with affected earnestness over technicalities, the twisting and wrenching of every means, honorable or dishonorable, to gain their petty ends, the dishonorable having the preference on the principle of reaching ends at the smallest cost.

The pupil must be made to realize the absolute necessity of study. In the words of Locke, "It cannot be too deeply impressed on the mind that application is the price to be paid for mental acquisitions, and that it is as absurd to expect the one without the other as it is to hope for a harvest where we have not sown the seed."

The myths of over-study are industriously exploited merely to becloud the fact of under-study, or no-study. The minds of high school pupils are apt to suffer, not from exhaustion consequent on excessive exertion, but from the atrophy resulting from non-use.

To secure any real results the pupil must be required to study. Naturally the best way of securing studious classes is to excite as much interest in the work as possible. But a period must come when either this method fails or the standard of work is lowered.

And as Bain aptly observes, "Sensation exhausts the brain quite as thoroughly as thought, and much more quickly."

The mode of securing studious habits by merely exciting the interest of the pupil by extremely concrete and simple illustrations is so evident and elementary as to be axiomatic. For present purposes it will be assumed as axioms are assumed; although it would no doubt bear a scrutiny akin to that which axioms have always demanded, but which until lately they have not actually received.

Mathematics is not uniformly interesting to the merely average student. His mathematical course can no more be made a continuous round of intellectual pleasure than his actual world life can be made a continuous holiday. Half the intellectual value

and well-nigh all the ethical importance of mathematical study lie in its training the pupil to be discouraged at no difficulty, and to shrink from no effort. Any alleged course that devirilizes the work by concealing, or eliminating, all difficulties and doing so much for the pupil that his own share is no more than that of a child in a kindergarten is *pro tanto* a mental and moral cheat.

The aim of education is to fit for life; much of the work of life is hard and uninteresting, but since it must be done, in any event, it should be done willingly and cheerfully, whether the worker sees the *rationale* of it, or not.

Van Dyke tersely puts the matter thus: "It is the resistance that puts us on our mettle; it is the conquest of the reluctant stuff that educates the worker. I wish you enough difficulties to keep you well and make you strong and skillful."

Even in the matter of interesting pupils it must be remembered that what interests one will not necessarily interest another, the mode of attack that captures the citadel of one mind with ease may be an absolute failure with a second. And herein lies the innate vice of most educational theories advanced by people that have never handled large groups of minds. Some average must be struck. Those above this average will be the more easily handled the smaller their number, i. e., the higher the average ideal. Those below the average must be brought up to it.

He who makes mediocrity his standard is foredoomed to failure. A human being is born, we are told, every second; possibly 10 or 20 births would be nearer the mark. How many centuries it takes to produce a Thales or a Euclid, a Plato or an Archimedes! How long was the world in intellectual darkness before the splendor of the mathematical names that will ever mark the individuality of the 16th and 17th centuries broke the long night!

These names are like the Himalayas—the absolute height none can question—the relative grandeur it is difficult, and perhaps not important to fix—where all are Titans, slight differences of stature are not important.

But these men did not get their mathematical training in kindergartens of either primary or secondary grade. Lying under an apple tree will not make a Newton any more than wearing a high crowned hat will make å Napoleon.

And here for suggestion we can look only to nature herself.

In the principle of the survival of the fittest we find the only tolerable method of forcing up to the average those whom indolence and indulgence keep dragging below it.

To those who lead unwholesome and morbid physical lives, sensations, and therefore physical desire or interest, can be no safe or even sane, guide. Who, then, will contend that the mental sensations of the mentally weak, or diseased, shall be made the *norm* by which the teacher is to direct the work alike of the sick and the well committed to his care? As well claim that if a number of blind children be forced into a class, by rule or otherwise, and it should further develop that a few more of the class were deaf mutes, the instruction should be conducted entirely on lines laid out by an Anne Madison Sullivan for a Helen Keller.

A pupil who can not read is out of place in a class in Shakespeare. It is useless to claim that he would never learn to read, no matter how long he were kept at the task. It is equally useless to pass a pupil forward in mathematics before he has mastered his preparatory work. Any school rule that passes such a pupil merely because he has spent a certain time in a grade, or class, is unjust to the pupil himself, to those who rightfully go forward, and to the teacher of the next class.

Herbert Spencer thinks that—

"If from the time when the child is able to conceive two things as related in position, years must elapse before it can form a true concept of the earth, * * * if the intermediate concepts are consecutively larger and more complicated; is it not manifest that there is a general succession through which only it can pass? That each larger concept is made by the combination of smaller ones, and *presupposes* them; and that to present any of these compound concepts before the child is in possession of its constituent ones is only less absurd than to present the final concepts of the series before the initial one? In the mastering of every subject some course of increasingly complex ideas has to be gone through. The evolution of the compounding faculties consists in the assimilation of these; which in any true sense is impossible unless they are put into the mind in the normal order."

The whole object of grading a school is lost when the pupils of an advanced class must be stopped and kept in idleness while the time of all is taken up in the instruction of the few dullards who should be in classes far below. The inscription over the

pylon of the Akademos was, "He who *does not know* geometry need not enter here." No question as to the number of years the postulant had studied, or the number of courses he had taken. The essential prerequisite was the *knowing* of the geometry. This should be the model of all classification systems.

The plan adopted in many schools of splitting the mathematical course into separate blocks, each carefully labeled and placed in its hermetically sealed compartment, is not to be commended. It violates the principle of continuity of thought, and renders impossible that correlation among its own branches without which mathematics cannot maintain its proper relations to the other subjects in the curriculum.

The usual course calls for the completion of the elementary algebra, then of the plane and solid geometry, after which comes trigonometry—followed in some cases by what is called advanced algebra.

A much better plan is to carry along the various mathematical branches *pari passu* so far as possible. Mathematics is a *continuum* not a concatenation. Under the present system the unity of the subject is never brought home to the mind of the pupil. He never gets a proper perspective. One third of his time is wasted in groping and stumbling; time that could be thoroughly utilized if he were working in the broad light of a proper comprehension of the subject as a whole.

Laisant, the well known French educational writer, expresses the idea thus: "That algebra, arithmetic, and geometry should be taught side by side is not merely useful, it is indispensable for maintaining that unity and coördination in mathematics, without which the science loses all interest and value. A boy who has taken his arithmetic first, then his algebra, and then his geometry, has his mental powers less developed than they would have been with three or four years of parallel teaching intelligently pursued."

In thus carrying the subjects along side by side, at least one period in each week outside the regular mathematical time should be devoted to what might be called laboratory work; that is, to an exercise for which no preparation shall be required of the pupil, but in which the class, as a whole, shall be drilled on the weak points of its work; while general interest in the subject shall be stimulated by rapid, but not difficult, exercise work, not

only covering the ground of the regular course, but, so far as possible, supplementing this course.

As a relief from mere problem-work in this laboratory exercise, I should strongly recommend the investigation by the class of mathematical fallacies. Many illustrations of these fallacies may be found, of course, in the works devoted to such subjects. DeMorgan and Ball are within reach of most teachers. But it is very easy to invent others, so that the class may be kept constantly on the alert. The detection of the error in a false course of reasoning is quite as good exercise as the solution of the ordinary problem, and while not always as easy, is often more interesting. The laboratory time should be so divided between the subjects that a fairly complete supplementary course may be worked out in each, but that, in any event, the interest of the class should not be allowed to flag.

In all work whether in laboratory or regular class, neatness of form, and accuracy of expression should be absolutely insisted upon. Clarity of thought cannot exist without accuracy of expression, whether oral or written, whether expressed in symbols or diagrams. Harmony and order in ideas should carry with them symmetry and elegance in the expression of those ideas.

(*To be continued*)

BOYLE'S LAW.

By C. D. Carpenter,

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The fact that the product of the volume of a given mass of gas, at a constant temperature, and the pressure under which it is placed is a constant, is known as Boyle's or Mariotte's law. It seems that Robert Boyle of England formulated the law in 1662, and Mariotte of France, without any knowledge of Boyle's discovery verified the same law in 1676. Thus in France it is known as Mariotte's law.

Nearly every pupil knows that a gas varies in volume according as there is a greater or less pressure upon it; but he does not know that there is a definite relation existing between the amount of pressure applied and the volume of the gas until he encounters the law just stated. For the proof of this law many pieces of apparatus have been made, simple in operation and

fairly accurate. It is my purpose to present an apparatus simple in form and differing little from some pieces already in use, but perhaps with some merit which will be brought out in a description of it and an explanation of its use.*

The apparatus is a U shaped tube, with a long and a short arm as shown in Fig. I. It is similar to the J shaped one in common use, differing in that the short arm is about 90 cm long with a glass stopcock C at the end while the long arm about 150 cm long opens with a small funnel into which mercury may be poured. Near the end of the long arm is a stopcock D by which the mercury may be drawn off. The extra length of the short arm enables the instrument to be used as a barometer. With the stopcocks C and D, the volume of the gas and the height of the mercury may be easily adjusted. The heights of the mercury columns are read by moving the detachable slide up or down on the graduated stick E. The glass tube and graduated stick are mounted upon a base 64 inches long as shown in the figure. The instrument may be supported by a hole at the top or it may be fastened permanently by means of screws. The slide F, as shown in Fig. II, mounted upon the scale stick A, has two arms d, d, made of brass, which extend over the glass tubes and may be made with a vernier attachment as indicated at a. The slide is held in place by clips c, c, made of spring brass.

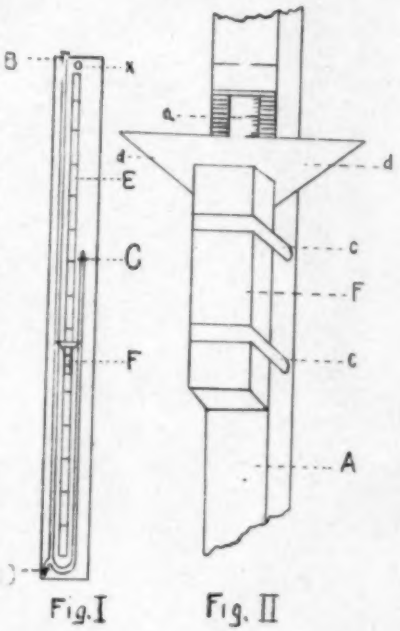

Fig. I Fig. II

In experimenting the stopcock D is closed and the one at C opened. Mercury is then poured in at B until it rises on the level in both arms just above C. C is then closed and by opening D mercury is drawn off until it begins to come away from C.

*The instrument was made in the laboratory at the Michigan State Normal College and tested giving very satisfactory results. In making the instrument aid was given by the professors in the department—Professors Strong, Peet, and Gorton.

The heights of the mercury in the tubes are then taken and the difference recorded as the reading of the barometer. If air is the gas used the stopcock C is then opened and mercury added or drawn off until the desired air column is obtained. C is again closed. If the original air column is about 30 cm then readings may be taken for air under pressure of more or less than one atmosphere. Mercury is then poured into the tube at B until full and the height of the mercury in each arm noted. Mercury may then be drawn off a little at a time by means of stopcock D and several readings made.

From the readings the following data may be found. The sum of the barometer reading and the height of the mercury in the long arm minus the height of the mercury in the short arm may always be used as the pressure, while the length of the short arm minus the height of mercury in it may always be regarded as the volume of the gas. Then if,

H=Height of mercury in the long arm
H′=Height of mercury in the short arm
B=Barometer reading
L=The length of the short arm

$$\text{Pressure } (P)=B+H-H'$$
$$\text{Volume } (V)=L-H'$$

and $P \times V$=a constant. Results may be recorded as follows:

BAROMETER READING 75.

			Pressure	Volume	Constant
H	H′	L	B + H − H′	L − H′	(B+H−H′)(L−H′)
150	75	90	75 + 150 − 75	90 − 75	150 × 15 = 2250
60	60	90	75 + 60 − 60	90 − 60	75 × 30 = 2250
10	40	90	75 + 10 − 40	90 − 40	45 × 50 = 2250

The same precautions as to pureness and dryness of the mercury and gas used must be taken as in any other instrument.

The instrument being made of glass, saves the contamination of the mercury by metallic or rubber connections.

With proper precautions very good results may be obtained.

COMMERCIAL GEOGRAPHY FOR SECONDARY SCHOOLS.*

By J. Paul Goode,

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Commercial Geography is one of the youngest claimants for attention in the school curriculum. It is a great field, well and widely recognized, but, at least in America, essentially unorganized. Commerce is old, older than recorded history, and geography is some generations old; but Commercial Geography, in English lands, is not yet fairly above the horizon. In our secondary schools the subjects that are well presented are those in which the teacher has an opportunity to get well grounded in the college and university. This accounts very largely for the strong hold which Latin has still in our schools. Some of the older of us can remember how the sciences began to come into the high schools. They have gained a foothold in these schools just in proportion as they have been well established in the universities. In the matter of geography they fare better in Europe than we do. College work along the lines of Commercial Geography is offered in nearly every German speaking university and in all the Technical High schools,—over a hundred places. In most of the French and Italian universities, too, nearly a hundred more, yet the subject is represented in barely a dozen English speaking universities. Truly there is some excuse for a lack of organization of the subject with us.

In the scope of Commercial Geography, as we have it presented, there are two well defined points of view, the commodity, and the country. Difficulties begin in trying to limit the field. What shall be said about commodities. What *is* the geography of commodities? There are some things we may well all agree upon: Areal distribution is geographic; so is the location of commercial centers; so are the routes of trade and most of the conditions determining these routes. But how about processes? Are they geographic? How far should they enter? We must pass judgment upon processes, according to whether they have a geographic bearing. Take the case of lumber. Why is the lumber so nearly stripped from the Great Lakes region, while a considerable resource,

*Read before the Earth Science Section Central Association of Science and Mathematics at its December 1905 meeting.

enough to last fifty or sixty years, still remains in the South? The answer is found largely in the processes by which the lumber is won. In the north when winter comes, rivers, swamps and lakes, frozen, become ideally perfect roads, making it possible to go anywhere with teams, and to draw extremely large loads with ease. While in the south the seasons offer no advantages. There are no roads anywhere, unless they are specially built,—an extremely expensive undertaking, and, even so, the roadway is inferior in every way to the frozen river of the north. So, loads are small, and lumbering is expensive.

Or, take the case of cotton manufacture. Why does starvation loom before the textile workers of Lancashire? Why is English textile supremacy threatened? Why did the King, in a recent message to parliament, dwell so earnestly upon the need of testing, in every available colony, whether cotton might not be grown there with profit? The answer is not to be found in any change in climate; nor in the question of fuel for power; nor in the facilities or efficiency of transportation; nor directly in any change in the labor conditions in England. The answer lies in the invention of the ring spinning machine. This machine makes it possible in all coarser spinning to substitute for the highly skilled mule spinner, a six-year-old "pore white" child in our southern states, and the three-cent labor of women and children in India and China. Thus the revolution is on, and the cotton instead of going to Manchester to be spun, is made into cloth in the region where it is grown, and woe settles down over Lancashire. The method of spinning a thread on the ring machine has nothing of geography in it, but its influence becomes geographic in a very real way, as truly as a variation in precipitation or an untimely frost.

In the next place how far shall we go in the treatment of a country? For an elementary course of a year, I am ready to say we can omit the country entirely. The ill logic of the political unit in geography is impressive, once it is challenged. It is true, statistics are national, more is the pity. But trade is inter-regional. And the conditions of production and transportation are mostly physiographic. Cotton grows best, not under a monarchy, or for Germans or Americans, but in tropic or subtropic temperatures, with seven months, at least, free from frost, with the proper mixture of sun and rain, and with good transportation facilities between the plantation and the loom, and be-

tween the loom and the consumer. Forests grow with given temperatures, and with certain annual and seasonal rain distribution, regardless of courts or parliaments. Animals thrive plentifully or sparsely according to the vegetable food supply, without regard to fiat or injunction. In short in all the geography of the schools the *State* is of the least importance, and for most of the educative part of school work could be nearly ignored. The drill on the purely political and little else, is a survival, like the vermiform appendix, or like the buttons on our coat sleeves. The Region is, it is true, a logical unity for detailed study; and even the country, at least the home country, will serve admirably for advanced work. All authors, so far, oscillate between these two points of view: Commodity—country, But with all respect to Mr. Chisholm and his followers, I believe the geographical element has been slighted in all this work, and we are overtaxing our pupils with mere dollars, and bushels and tons,—which is not education.

We can't do everything in one year. We are attempting too much. Suppose we give up the countries in our elementary course, and make the scope of the first year *Commerce, and Commodities.* It makes a field big enough in all conscience. I would suggest the following:

ANALYSIS OF AN ELEMENTARY COURSE.

I. Commerce.

1. Conditions controlling commerce: The principles of trade; unequal endowment of regions, in advantage of position, in relief, minerals, soil, climate, the character of vegetation, industrial development, and standard of living of peoples.

Government interest: Control of shipping, suppression of piracy, fixing of conditions in land transportation, tariffs, bounties, establishment of ports, the consular system, colonization, education.

Organization of industry: Establishment of standards: weights, measures, time, money; establishment of the market, and the settling of accounts; organization and training of labor.

2. Means of transportation: Conditions and forces of land transportation; of water transportation; function of waterways in fixing rates; character and significance of harbors; the logic of ocean routes.

3. Safeguards to life and property: Elements of safety in land transportation; charting the coasts and seas; lighthouses; storm warnings; life-saving service; quarantine; inspection; insurance.

4. Means of communication: Society as an organism; the postal system; the parcels post; ocean cables; the telegraph; the telephone; wireless transmission.

5. Commercial tendencies: From luxuries to necessaries; the equalizing of prices and supplies; the territorial division of labor. Movement of population, to cities; winning the tropics. Educational tendencies.

II. Commodities.

1, The product of mines and quarries and wells: Coal, iron, gold, stone, water, etc.

2. The products of hunting and fishing: Furs, ivory, game, fish.

3. The forest resources: Lumber, fuel, gums and resins, fruits, textiles, dyes, drugs, etc.

4. The significance of the soil: Origin, translation, drainage, irrigation, maintenance of fertility.

5. Products of the farm, orchard and range: Cereals, roots, fruits, textiles, domesticated animals and their products.

6. Manufactures: Foods, clothing, shelter, arts, machinery, etc.

7. The forces employed in manufacture and transportation: The muscles of man and beast; wood and coal for steam; water power, and other sources of power.

This in itself is a very large field. We cannot go much into detail in all these topics, and we do not need to. "One need not eat the whole pudding to know how it tastes." Out of the long list of topics we may choose some as types, and treat them fully; coal, the forest, corn, cotton, etc. Go fully into the physical factors involved in production and distribution and in the journeys of the products to manufacturer and to market, regardless of political boundaries; with an eye always to the way in which the industry reacts upon the people,—producer, carrier, consumer. For the human element is the substance of a permanent and universal interest. It is dominant in Commercial Geography, a proper study of which lays a foundation for the serious study of sociology, and for the solution of many social problems.

To present the study properly we need to take for granted: (1.) The simple geography of location; the knowledge of the map; the form, size and space relations of the continents. (2.) Elementary physiography, with its knowledge of the evolution of earth forms, and (3.) a much more adequate knowledge than is at present given of the elements of meteorology,—the circulations of air and sea, and their significance in climate.

In presenting the subject the prime requisite is, of course, the teacher, and the character of his preparation needs to be carefully looked after. He must have wide interests and an insatiable appetite. He ought to approach his subject through the natural sciences. He needs to be well grounded in geology and physiography, and to have had special work in climatology. In biology, too, he ought to have had special training; in botany something more than the names of the species, valuable as this may be; he needs all he can get of ecology. He must be able to trace with considerable accuracy the intimate dependence of organ and function upon the varying conditions of light, heat, moisture, and soil. In zoology, too, he ought to have a familiar acquaintance with a type form in each of the great phyla, and to know at first hand how changes in the elements of the physical environment invite changes in the organism, and that man is no exception to the rule. These natural sciences are fundamental to an adequate study of man and his institutions, and elementary courses, at least, in economics and sociology should follow as a part of the teacher's necessary equipment. Add to this a comprehensive training in general history and a reading knowledge of French and German, and we have the main lines of a liberal education, as well as a very excellent preparation for a specialization in Commercial Geography. It would be well if in vacations and the interim of the mastery of many books, the youth has had a chance to get some experience in the actual mechanics of some of the trades. To have earned his bread by the sweat of his brow on the farm, or in the mine, or foundry or mill,—this is a training worth more, as a part of real preparation, than all the frills of an ordinary education. For if he knows *work* and the condition and horizon of the worker, it will prove a source of endless interest and profit.

His power as a teacher will lie largely in an ability to inspire thought. This he may do by a logical presentation of the fac-

tors involved, with the causal relations always in view. The "why" questions must be constantly in evidence, and the nimbler he is in tracing effects back to causes, the better.

The next requisite is a text. By all means have a text. It saves work and worry. At least it is a convenient reference book of facts. In several cases at present it is little else. Chisholm is the pioneer of all the English texts, and he remains the best of them all. He covers all commodities, and all countries too, to 700 pages of closely printed octavo. All our American texts are fashioned after Chisholm, and our best school text was not even written by a teacher. They all attempt to mention all the things and places Chisholm does, and get it into a duodecimo book of 350 pages. Such condensation is dangerous. It almost comes to be a dictionary of statistics, and of more or less unrelated facts. It is likely to cause mental indigestion. In its extreme condensation it is not education, and largely not geography. For let us not forget that education does not consist in memorizing statistics, nor in conning catalogues of things, any more than in memorizing capes and lists of cities. Education is achieved in the power of thinking; in the ability to trace effects back of causes; in finding out the why of things. And there is no subject more full of problems to be solved, than is Commercial Geography. What has the position of the world's great highlands to do with the commercial suupremacy of the Atlantic? What geographic handicaps have Boston and Philadelphia in commercial competition with New York? What is the effect of the Great Lakes and Erie Canal in fixing railway freight rates in America? What is the dominant factor in England's commercial power? What great social advantages are there in agriculture by irrigation? What can plant breeding do to increase the world's wealth? What part has cotton played in fixing social status and political attitude in the South? What is the economic significance of the discovery that the mosquito is the immediate cause of the spread of malaria and yellow fever? What industrial revolution is coming as coal grows scarce and dear? What powerful political and social influence grows out of the fact that England produces only seven per cent of the bread she eats?

There are thousands of these questions. They meet us at every turn. They cannot all be solved. But they can be opened up. We can, at least, begin to think along these lines.

These and kindred questions invite research, and send teacher and the student to the library. And to become independent in the use of books and printed material generally, is one of the best things a student may learn. The work can be taken up topic by topic, and teacher and class may bring to it contributions from a wide reading, special references being assigned to certain students to be reported on. Then each should have at least one topic per term, upon which he may acquire a wide margin and an "easy mind",—a taste in real research. His written report on this is the best kind of exercise in English composition, and is better than an examination as a measure of the real power of the student. This also puts the library to the test and brings up out of the dust a wealth of material otherwise untouched. Not until such a subject comes along do we begin to realize the extent and value of our government publications. No other government is doing so large a service in scientific advance in productive lines, as our government is doing. In the Department of Agriculture alone over sixty serial publications are issued nearly all of which are grist for our mill. So, too the Departments of the Interior and of Commerce and Labor, to mention only two others, are issuing an enormous amount of very valuable matter for our work. And most of these publications may be on the shelves of each school as issued, if the teacher is alive to his opportunities.

A very valuable adjunct to the text and to the presentation is a generous list of maps and graphs. And it is no disadvantage that for the most part graphs have to be made as used. Their best use is in showing a trend or tendency, or in making direct comparisons. Thus the increase in output of a commodity through a term of years, or the direct comparison of one region with another, in production, or of one commodity as compared with another, is shown to the eye at a glance, and in a way to be remembered. The graph is the shorthand of statistics, and with the map is one of the teacher's strongest appliances. The number of side-lights that can in this illustrative way be brought to bear upon a topic is surprising. For example, studying corn in the U. S.: We want maps showing the distribution of glacial soil; of highlands and lowlands; of the annual rainfall; a graph of rain distribution by months in the growing season in the central region of maximum production; maps showing a sequence of cy-

clones, and the way the rain is drawn in from the Gulf and the Atlantic; charts of the earliest and latest killing frosts; a graph of season lengths free from frosts; a map of corn production per square mile, and in at least two tints to bring out the region of maximum production; map of corn production per acre; graph of corn production through the century, with the other cereals in comparison; map of hogs per square mile; map of cattle per square mile; map showing the location and magnitude of the great packing centers, of the dairy center, and of the distillery centers. These maps and graphs can easily be converted into lantern slides and made available for use before the whole class. In fact, with a lantern, any fine map in atlas or book may be converted into a large wall map, in color, for about a dollar, and one could carry a hundred such maps in his hands at once. Thrown on the screen, all the class may be studying the one map at the same time and the recitation may be going on from the map. With the lantern, also, there is a world of illustrative material available in the way of photographs. The possibilities of the lantern in instruction are very great, and, I fear, not yet appreciated.

The actual material of the commodity in its various stages of preparation and manufacture has a high teaching value, and a museum is an ideal adjunct to the library. For example, the silk moth, the cocoon, and silk, raw, spun, reeled, woven and dyed. Or petroleum, raw, and in its various products from benzine to axle grease, and from patent medicines, to chewing gum. Or corn, the stalk, husk, and ear, and its products from meal and pone to starch, table syrup and whiskey, or from husk mats to parchment paper and smokeless powder. Or again, the actuual rubber from sap to vulcanite. The list is almost endless, and it is not difficult to start the museum. Manufacturers are often good natured, and are glad to co-operate. But I should not advise any school or teacher to accumulate material without dust proof and locked cases to protect it. Waiting for cases however would bar most schools at present from having materials to use, and it is very gratifying to know that beginnings are already made in series of traveling museum collections, which have been provided in Chicago by a Museum Association, and in Philadelphia by the Commercial Museum. These collections are available at little or no expense to the school, and one collection may

visit thirty or forty schools in the course of the year. This is an excellent work, and well worthy of finding favor in many other places.

Next to the museum is the excursion. To visit the factory or the mine, and actually see the work in progress, and the workers under normal conditions of production, is an education in itself. This is most valuable when following the topic which the work illustrates. Thus, following the study of iron, a visit to the rolling mill or foundry, clinches the study as nothing else can. An itinerary may be provided beforehand calling attention to the things and processes to be seen, for people usually see what they are looking for. A written report after the excursion will add much of value, and will be helpful as an incentive to careful observation.

The subject of Commercial Geography properly presented stands as a logical connecting link between physiography and biology on the one hand, and history, economics and sociology on the other. The student properly trained in it will have his eyes open to a multitude of the great problems of modern society and will be well started in a way to know the forces involved and the method of solution of these problems. Above all he will be impressed with the idea that things do not happen,—they are caused, and that even social and economic problems may be solved by study and thought.

STRUCTURE OF HAILSTONES.

A curious fact was noted some years ago by a close observer, namely, that hailstones when melting away in a pail of water end their career by giving up a large bubble of air which had evidently been enclosed under great pressure in the white snow that forms the center of the hailstones. We hope that many of our observers, regular or co-operative, may have the opportunity to repeat this observation and will send us the results, whether positive or negative. Observe as closely as possible the size of the cavity that appears to contain the air and also the size of the bubble of air as it ascends through the water. In fact the latter measurement may be made quite easily by using soap suds instead of pure water and measuring the size or volume of the soap bubble. Many hailstones should be measured so that we may figure on the variations that must occur between them.
—*Monthly Weather Review.*

SHALL THE COURSE IN BIOLOGY IN SECONDARY SCHOOLS CONSIST OF ONE-HALF YEAR ZOOLOGY AND ONE-HALF YEAR BOTANY, OR A FULL YEAR YEAR OF EITHER SUBJECT?*

By G. H. Bretnall,

Monmouth College.

This question can only be settled or even discussed in the light of what the student has in view in his course; or, perhaps better, by a decision, on the part of those shaping the course, of what the student should gain from his course or any part of it which is considered. This first settled then it may be adjudged whether one-half year in zoology and one-half year in botany, or a full year of either zoology or botany carries out the idea, and accomplishes the end sought.

The point of consideration is whether the course is to be made as a college preparatory course or without regard to the college at all. We may say, however, that the two standpoints may be made one. The discipline and training necessary for college entrance may, also, be such as would fit one for practical life. We are getting away from the idea of courses for discipline alone and whether the course be that for general culture only or for college entrance it should have its practical side. Furthermore, no course should be planned with the idea that the student's work in that line is compassed in that course; but whether he attends college or not he should receive inspiration to further study, whether he has the privilege of college assistance in that further study or not. While a high school course does not and cannot prepare for research, if it fails to lead the student to further study in the same line it fails in doing part of what should be its object. It may be said, moreover, that every high school student should be urged to attend college and his training should be made as an inspiration to that, and with that in view.

It is necessary, now, to consider what ends are to be sought in this course of study. These ends it seems to me can be divided into five divisions; namely:

(1) The best mental habits with the best mental training and development.

(2) The ability to think for oneself and if only in a very limited way to find out facts for oneself. This would include

*Read before the Biology Section of the Central Association of Science and Mathematics Teachers at the December, 1905, meeting.

the ability to use the facts gained, to judge something of their value, to be able to draw some conclusions from data.

(3) The most usable information, the most cogent facts connected in such a way as to have some significance to the subject as a whole. This, with the greatest amount of retainable information.

(4) Giving as far as possible a practical bearing to the course; that is, relating it to everyday life.

(5) The bringing of the student in touch with nature; opening his eyes so that he may see things about him; so that his æsthetic tastes may respond to his environment; that his surroundings may become beautiful to him instead of commonplace; in short, that he may fall in love with nature.

It remains for us now to consider what reasons may be advanced for each course of study in question by considering what the student will acquire in each course. Then we must show how the above objects will be carried out in the one case or in the other.

We shall discuss the two short courses first: There is a value in getting a view of both sides of biology. This is especially true for those that do not go to college, and true for those that do. Both lines are opened. Whatever may be the future of the student, he ought to know something of both sides of biology. A student can hardly be said to be educated, even in a high school sense who knows nothing of botany; who knows nothing of the principles at work in the woods, fields, and parks around him; to whom the plant world speaks nothing except in a superficial way; to whom plants are only flowers, weeds, or scum. On the other hand is he educated when he knows nothing of the manifestations of life in the animal world; of the bee and butterfly around him; the toad in his path, or the dog of his sport; to whom all animals are bugs, worms, birds, or beasts, and nothing more? It would seem that a school board would feel great hesitation in granting a diploma to a student and in sending him out as a product of the American public school system when he is not acquainted with the world in which he is to live by an intelligent understanding of both plant and animal life.

Again, it is not known in what sphere of life the pupil is to be put, so if his education is to have any practical turn at all he must have both sides opened to him that he may use it for any practical work or study that he may need. Further, the study

of biology may open to him his future vocation. He must know both sides if he is to choose wisely. An education should help or rather perhaps, enable a student to find himself. His life's aim should be set in high school, that his future education and work may be planned intelligently.

Do the short courses accomplish the objects we have in view?

If there is to be a mental training a broad view must be given. If the student is to have right mental habits he must be taught to make wide comparisons. If his knowledge is to be true he must know the manifestations of principles in both animal and plant life. He must compare their oneness and their differences if he is to understand them rightly. If he is to fall in love with nature and get in touch with his environment he must get a general view of that nature and environment.

I believe I have set the arguments for this side in their strongest setting and whatever they may show or may not show, I think these facts do show the necessity of a general training in biology.

But there are things to be said on the other side. The ideal is a training in both lines but if time is too short for this we must do only the possible. It is best not to sacrifice both courses for the sake of one. Keen as may be the need of a general training in biology, enough time is not allotted to it, so of two evils the lesser must be chosen.

There is value even, in being limited to one side; for the instructor usually has more interest and training on one side than the other. While we may hope that he is not so narrow as to forget that there is another side, yet he can do best in the line in which he is most interested. To see that one-half year is insufficient for each branch we may look at what is necessary to be done in each case.

In the first place it should be said that an introductory course should be an introduction to the subject, and in a general way should show the field to the student. In botany he should get a knowledge of what is comprised in morphology, physiology, and ecology. While in a year the ground cannot be covered in these lines even in an elementary way, yet a view of the field can be given. A view of the ecological societies, with the ecological factors and structures can be given with the aid of a little field work. A few of the most important principles of physiology can be studied and illustrated so as to give a foundational knowledge

of plant functions. The most time must be given to studying and illustrating the plant groups, with especial emphasis upon the seed plants and particularly the angiosperms. This morphology work is really the work in botany for secondary schools; an understanding of what is comprised in each group, with a study of enough specimens to make the knowledge tangible. This includes a structural comparison, a study of reproduction, and an understanding in a general way of evolutionary sequence. In the seed plants the structure should receive fuller attention than is given to the lower groups and should include some work in histology. This work necessitates the use of the microscope. A student should learn the use and manipulation of this instrument in his secondary school work. He should learn to interpret by it. It is not wise to turn a student into college without knowing its use, or out into life without the facts it only can teach. There is a feeling to-day that something else can be substituted for it. I believe in field work in ecology, and believe in giving the physiological principles their rightful place of illustration in the laboratory. The plant cannot be understood without these things. This does not take the place, however, of the foundational work to be done with the microscope, for only thus can a student get the proper grounding in the subject.

It is very clear that the work as outlined cannot be done in one-half year. One year is a short time for it. If the work is attempted in one-half year it is crowded and very imperfectly done. Right relations are not established and some topics are hurried over in a very superficial way. The subject loses its harmony and interest.

What is true for botany is true for zoology. We have the same subjects perhaps but a different arrangement of work. Here the foundations must be laid by a study of the different phyla. Some representative type must be studied for each phylum. Its structure, function, and life habits must be given consideration. That this may be done, most of these forms, those that are not so small and transparent that they can be studied whole by the microscope, must be dissected. While other work, as life habits, has its place, nothing can take the place of dissection. Casts and charts give only imperfect ideas. Even ready dissected specimens mounted in glass jars do not have the value of specimens dissected by the student. The knowledge gained by dissection is first hand and leads to exactness. Only thus can the student

get that knowledge of structure which is necessary to a right understanding of the animals and of animal structure in general. All work without this is more or less superficial. The student has too much of a tendency to review things only in a general way without looking closely into details. The other habit, of careful examination by dissection, and of careful study of the parts needs to be cultivated. The life habits, the adaptation to environment, the ecological side cannot be understood without a good knowledge of structure.

It is as plain here as in botany that if this work is to have any thoroughness at all, a year must be given to it, else much of the work must be slighted or carelessly done. A year is all too short. In one-half year the laboratory work must be hurried and imperfect. There will not be time for a careful consideration of even the limited amount of work done.

A course may be given in zoology by simply studying a few forms without regard to comparisons, classification, or developmental sequence. Such a course, thorough as may be the study of any individual form does not, to my mind, give the thorough, all-round training which comes from a year's course such as that of which we have spoken. This is not an introduction to zoology any more than picking out one circumscribed subject in botany and giving that as a course would be an introduction to botany; or to use a familiar illustration it is no more an introduction to zoology than the old systematic botany and herbarium was an introduction to botany. Both were but parts of the general field and not perhaps, even foundational ones. The zoology study should be broad in its views, should include principles of development, principles of life in general, and should be illustrated with as diverse forms as possible and with the general range of life in view.

To sum up and to see how these courses accomplish the ends which we have in view:

A short course is necessarily superficial and gives the student bad mental habits. It is not thorough and therefore does not give the right training and development. He has not gone deeply enough into the subject to think in it and therefore think for himself and find out facts for himself. He has not had time to study data sufficiently to be able to draw from it simple conclusions. He has not mastered thoroughly the most significant facts nor gained a great amount of retainable information.

The practical application of the subject must be left aside. As to bringing the student in touch with nature the short courses give him a wider view but the long course gives him a deeper view and therefore more love for the subject.

The short courses then contradict our ideals while the long courses more nearly accomplish the ends in view.

While it would be better to study both sides of biology if there were time, the time being limited it is better to study one side well. The student thus has acquired habits which will help him in taking up the study of the other side by himself or in college later.

COMMENT ON DR. MILLIKAN'S ARTICLE IN THE FEBRUARY AND MARCH ISSUES.*

By LeRoy D. Weld,

Coe College, Cedar Rapids, Ia.

I am thoroughly in sympathy with the writer's contention concerning the omission of certain incomprehensible formulæ from courses in elementary physics. Familiarity with the concrete phenomena of the science and definite ideas concerning the kinds of magnitude studied are absolutely prerequisite to the mathematical abstractions of more advanced courses. I feel this keenly when students come to me for instruction in analytic mechanics without any notion as to the nature of inertia or the difference between a pound of mass and a pound of force.

With regard to the substitution of the wave-front for the ray standpoint in the study of geometrical optics, it is my practice, in lecturing on the theory of light, to develop the formulæ for focal lengths and positions of images first by the ray method, and then by the wave-front method, thereby treating the subject in historical order. The wave theory of light has to be argued into existence and defended before a class of keen students, and the marvelous agreement of the mathematical results based upon it as a working hypothesis with those of the purely geometrical ray method usually sweeps away the last objection. It seems to me, however, that the mathematical phases of the subject are rather too difficult for students not familiar with analytic geometry and calculus.

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* This is one of several comments of the same general character which have been received concerning Dr. Millikan's article.—Editor.

SIMPLE METHODS OF SHOWING PRESENCE OF NITROGEN IN NITRATES, ETC.

By Oscar R. Flynn,

High School of Commerce, New York City.

These experiments can be carried out by the student and are recommended on account of the simplicity of the manipulation. They may be taken up after the pupil has learned that ammonia contains nitrogen.

To show that sodium nitrate is a compound of nitrogen, proceed as follows*: Put a few grams of zincdust into a test tube; add enough concentrated solution of the nitrate to make a thin paste, then boil. The odor of ammonia can readily be detected in the vapor escaping from the test tube. If the heating is continued too long the mass deflagrates and the test tube is broken.

A slight modification of the preceding experiment will serve to demonstrate presence of nitrogen in nitric acid. Put a few drops of strong acid into a test tube. Add two or three grams of zincdust. No heating is necessary. In a short time the whole mass froths up and a mixture of steam and ammonia escapes. The odor, if tested at the right time, will be found to be fully as strong as that emitted by a concentrated solution of ammonium hydroxide.

To obtain ammonia from nitric oxide use the following procedure: Pass the gas into ferrous sulphate solution. When a considerable volume of the gas has been absorbed, add an excess of sodium hydroxide solution to the dark liquid obtained. The resulting mixture of moist ferrous and ferric hydroxides gives off an unmistakable ammoniacal odor, the nitrogen of which must have come from the nitric oxide.

Production of *liquid carbondioxide* in Germany in 1904:

24,000,000 kg. produced.
22,000,000 kg. consumed in Germany.
2,000,000 kg. exported.
16,500,000 kg. were from natural sources.

***The editor has used aluminum, wire and sheet, very satisfactorily a little heat to start the reaction is all that is needed.**

THE INTENSIVE METHOD IN CHEMISTRY.*

By John F. Woodhull, Ph.D.

Teachers College, Columbia University, New York.

In nearly every presidential campaign we are called upon to hold opinions on some difficult problems. We feel obliged to vote when we have only inklings of the truth. It may take two or three campaigns on a particular subject to enable us to acquire knowledge that we may clearly define. Questions which puzzled the most astute minds a few years ago are clearly understood by the average mind of to-day.

This is the way we have gained our knowledge of the principles of chemistry. First came inklings of ideas. They may have been ruminated upon but they were forgotten as much as we ever forget anything. After a time we again met these ideas and were startled perhaps to find that we comprehended them much more clearly than before, as though the mind had been doing some unconscious work upon them meanwhile. This experience may recur many times with regard to the same idea until finally, after several years perhaps, we see the truth with clearness.

This seems to be a law under which the mind must work. A law which we must reckon with in teaching. We speak contemptuously of our modern newspaper civilization with its smattering of ideas, but is there proof that men of any other age ever did or ever can acquire knowledge by any far different method?

Now it sometimes happens that men, who have spent several years passing through this sort of experience in the study of chemistry and who have arrived at pretty clear ideas themselves, undertake to teach these ideas full-fledged to beginners. Thoroughness and accuracy are their aim. To go slow and cut a clean swath is their method. They are champions of the *intensive* as against the *extensive* method. They demand of beginners definiteness, sureness, and completeness of knowledge, and they attempt to make a few quantitative experiments furnish what time and extended experience alone can supply.

Teach chemistry to beginners—old or young—for one year, by whatever method one may choose. When they are examined upon the subject the next year their ideas appear to be exceedingly hazy. This is of necessity so. It is a law of the mind and teach-

*Read before the New York Chemistry Teachers Club May 12 1906.

ers should not be ignorant of it. College professors undertake to examine these products of the high-school chemistry class and are amazed at the results, and their judgments of the pupils and their teachers are very unjust. To mitigate as far as possible the severity of these unjust judgments, pupils are put through the senseless but very effective process of cramming the answers to questions used upon recent examination papers.

It happens that a large number of students take their first year of chemistry work in college and the assistants, whose duty it is to read the papers, can testify that college students at the end of their first year's work in chemistry have a phenomenal faculty for giving vague and strange answers to examination questions.

If one teaches a topic three times over, (1) as completely as he can in a lecture, (2) as thoroughly as he may in the laboratory, and (3) by the study and recitation of a text-book, even though he may succeed in making the pupil understand each step, he will find a few weeks later that the pupil has no realizing sense of the matter. He is like a person who answers questions correctly when half asleep.

Pupils in the kindergarten and elementary school like repetition. It is the only means by which impressions are made upon their brains. High school and college students have not passed beyond the operation of the same law. The justification for carrying along simultaneously the three methods of instruction —lecture, laboratory work, and study of the text-book—lies in the necessity for reiteration. This also furnishes ample justification for giving college students a course in general chemistry even though they may have had an excellent course in chemistry in the high school.

A year's course of laboratory work consisting of thirty-five experiments most quantitative, with little lecture work and little text-book work, furnishes too little repetition and too little perspective. When each experiment alone by itself is intended to establish one principle it fails by its meagerness. Better have thirty-five groups of experiments, each group containing experiments which are closely allied, mostly qualitative and all calculated to give different points of view of the same subject. Some experiments should be quantitative but generally each quantitative experiment should be preceded by several of a qualitative nature upon the same subject. Some quantitative experiments should be assigned to the lecture and some qualitative experi-

ments should be made laboratory work. Induction and verification may play a minor part in the course, but all experiments, whether used for lecture or for laboratory purposes, should have the main purpose of making the subject *real*. I do not object to intensive work nor to quantitative experiments. We may admit that they are the cream of the whole matter and yet insist that like the nutritive part of food, they must be mixed with a large bolus if digestion is to proceed. Certainly "the notion that an experiment is a vehicle for training in accuracy primarily is a very harmful superstition."

We teachers of chemistry need to take courses in applied science, we also need courses in biology, physiography and other allied sciences in order that we may give a practical turn to our teaching of chemistry. The time must come when we shall give the higher degrees in education at the university for such broad work as that quite as much as for the more narrow specialization.

There are at least three reasons why we should teach principles always with reference to their applications:

1. Our pupils get no correct appreciation of the principles themselves until they see their applications. A subject becomes a science only when its principles are related to something.

2. The subject must be taught with reference to its practical application not only for commercial purposes but also for the sake of human interest and culture. That is a very preposterous claim that our friends who call themselves humanitarians make—that their subjects alone contribute to human interest and human culture. It would be easy for us to establish chemistry in the hearts of the people as *the humanity par excellence,* and it is our duty to do that.

3. We must make our subject practical for commercial reasons. It is our duty to do all in our power to help our pupils to earn a living and become useful members of society.

Chemistry is the best of all subjects to lend itself to the logical and scientific development of principles. The topics may be so arranged that each one shall present further illustration of foregoing principles while adding new ones. In this way the last half of the year may be almost wholly reiteration of principles with increasing power to predict their applications in new conditions. Here is where our training in induction comes in.

As for the main results to be sought I should say that, if a

pupil understands his text-book in chemistry as well as the average pupil understands his history, we ought to be satisfied. I do not agree with those who speak slightingly of text-book work in general or of the existing text-books. There are a dozen or two text-books for high-school use which are very good indeed, and it would be a distinct gain if we should abandon the practice of making syllabuses and admit to college students who have been certificated as having completed any one of these text-books with appropriate laboratory work to make it *real*.

HOW TO MAKE A HYDROGEN GENERATOR.

By R. H. Kenyon,
Rochester, N. Y.

Several years ago I hit upon a plan of making a generator which proved in every way reliable, and anyone following these directions I am sure will find no difficulty in constructing a serviceable piece of apparatus at a cost of but a few cents.

The only material needed is a battery jar (See A Fig. 1), a bottle (B), a one hol d rubber stopper with glass plug to fit, (C and D), a short piece of lead pipe (E), a square of thin plank, (F) and a little rosin. I shall give no exact dimensions but the proper proportions may be readily understood from the drawing.

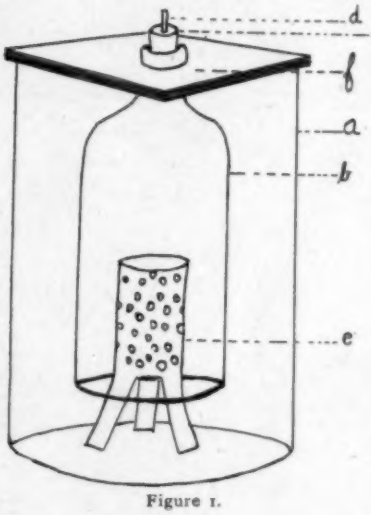


Figure 1.

The lower part of the bottle must be cracked off so as to make it about an inch shorter than the height of the jar. This may be done by heating the line where the crack is to occur with a curved piece of wire heated to redness and then plunging bottle into cold water. Then cut a hole in the center of the wooden square, just large enough to admit the top of the bottle with pressure, after doing which pour melted rosin between wood and glass to hold it firmly in place. Now put the glass plug in the rubber stopper and place in bottle.

Next take the piece of lead pipe and mark off circumference at end into six equal parts. (See Fig. 2.) Then saw parallel cuts at each dividing point lengthwise with the pipe about two inches long. A hack saw is the best tool for this purpose. Several holes must now be cut or drilled through the uncut por-

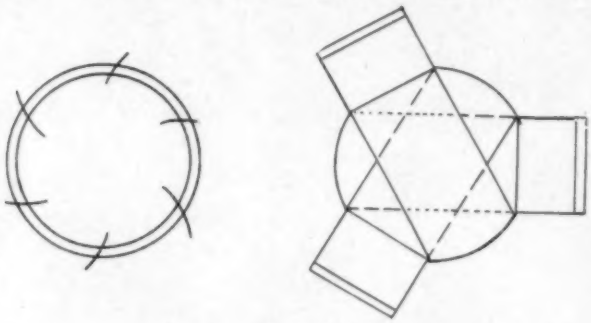


Figure 2.

tion of the pipe and three alternate strips cut off so as to make them equal in length to the inside diameter of the pipe, and bent in so as to close the cylindrical portion of the pipe at one end and form a sort of basket which will stand on the three remaining legs.

The generator is now ready to set up and the diagram (See Fig. 1) will give one the proper idea. Partially fill the lead basket with granulated zinc and after spreading its legs a trifle so as to cause it to stand firmly place it on the bottom of the jar. Now pour in enough dilute sulphuric acid to completely cover basket and suspend bottle over it by wooden cover affixed.

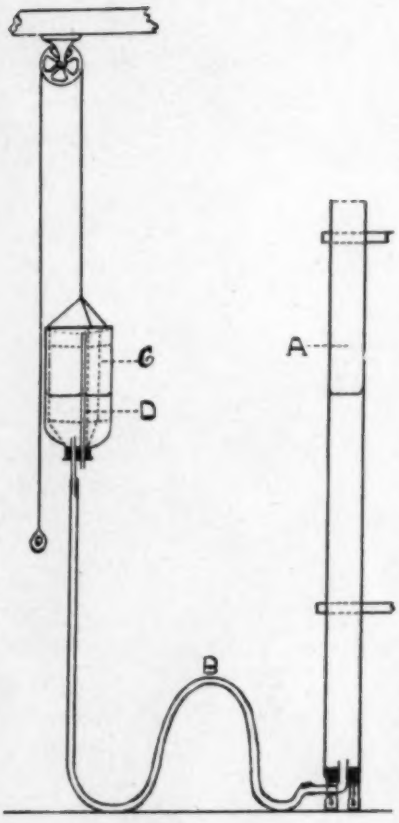
The generator is now ready for use. Pull out the glass plug. The acid rushes into the bell jar and into the basket coming into contact with the zinc. Hydrogen is formed and escapes under pressure through stopper, from whence it may be conveyed to any point through tubing. (Care must be taken after fresh filling of generator, not to light hydrogen at point of escapement until after all air in the bell jar has passed off.) To shut off hydrogen, replace plug. Hydrogen soon forces the acid out of the bell jar and chemical action in generator cases. By using iron sulphide or marble in place of zinc, a hydrogen sulphide or carbon dioxide generator is formed either of which is equally efficient.

Some of the good points of this generator are, its constant pressure, its ever readiness, and the perfect safety attending its use after once the air has been forced out.

A NEW FORM OF APPARATUS FOR FINDING THE VELOCITY OF SOUND IN THE AIR.

By A. Haven Smith,

Sioux City, Iowa.



A satisfactory form of apparatus for finding the velocity of sound in air does away with the spilling of water and enables the pupil to work rapidly and accurately.

The tube A, which is about one and one-half meters in length and four centimeters in diameter, is fastened securely to the wall. A corner of the room is the most convenient place to set up the apparatus. In the bottom of the tube is a one-hole rubber stopper through which passes a glass tube about five millimeters in diameter. This is connected with the rubber tubing B which in turn joins one opening of the bottle C. The tube D forms an opening for the entrance or escape of the air thus making it possible to use one of the many empty bottles to be found in every laboratory. A cord is fastened to the bottle and made to run over a fixed pulley. Sufficient water to partially fill the tube is poured into the tube and as the bottle is raised or lowered the length of the air column is changed accordingly. By the use of a proper amount it is impossible for the pupil to spill any of the water. With a tube 150 cm in length, the pupil may be required to find two or even three places of reinforcement and thus secure results of greater accuracy.

STUDENT ELECTROLYSIS IN A BEAKER—A NEW APPARATUS.

By Walter D. Baker,

Shortridge High School, Indianapolis, Ind.

The design of this apparatus is due to the belief that increased attention should be given to electrolysis. This is necessary, (1) because of the increased use of electrolytic operations in the chemical industries, and hence of the frequency with which we must study these operations even in elementary courses; it is necessary, (2) because it furnishes splendid experimental facts that call for an extension of our atomic and molecular hypotheses, viz: the ionic hypothesis. This the secondary pupil is capable of using; he does use it with profit; and indeed he must use it to interpret much of the work that we ask him to do.

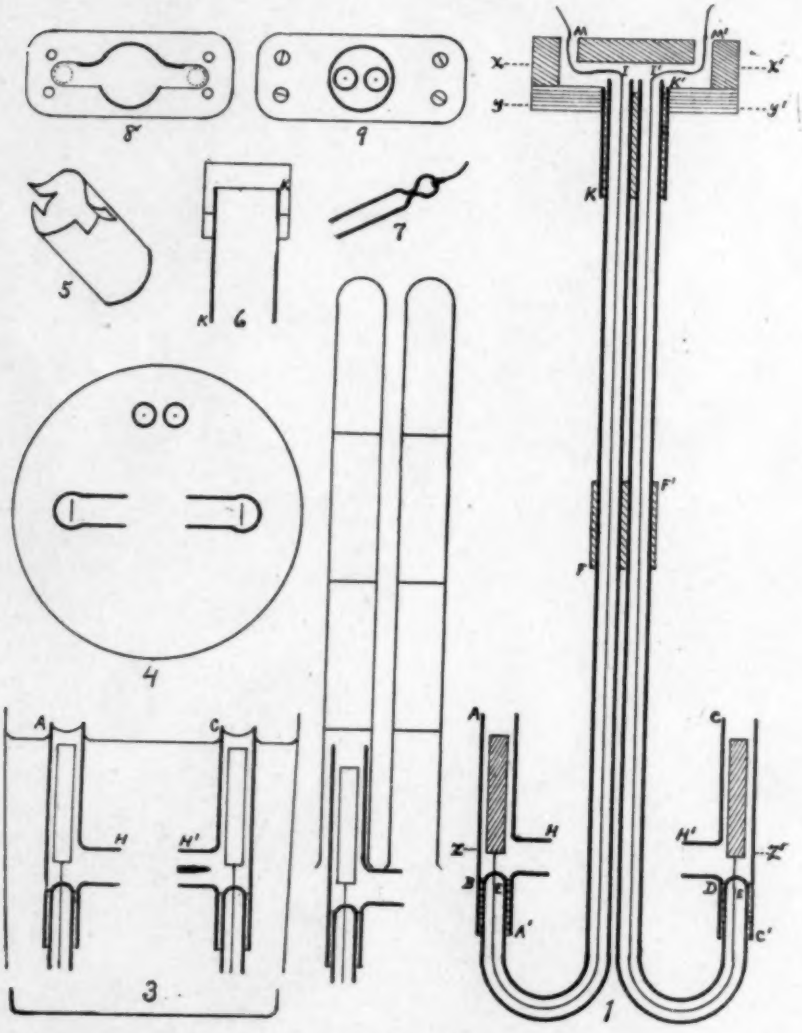
The apparatus is intended to bring out some experimental facts so fully and so easily that the use of this hypothesis will seem necessary, not only to our own mind, but also to the mind of the pupil. The latter is the essential thing. It is intended to show more facts than the ordinary forms of electrolysis apparatus, and to show them to the pupil on his own desk. The Hofmann apparatus shows a few facts only. Its cost and fragility confine it to the teacher's table. Other forms either show no more or else have features which prevent their being put on the desks in sufficient number for the pupils to do the work.

It is attempted in this apparatus to embody the following desirable features: (1) possibility of home construction; (2) cheapness to admit of duplication; (3) durability in the hands of pupils; (4) ease and quickness of manipulation; (5) need for a small quantity of electrolyte; (6) permanence of construction, so as to be kept intact when not in use, and quickly put away and gotten out again: "Once made, always ready for use" is the motto that gives the busy teacher time; (7) wide range of use, to enable the pupil to study, under direction, not only the substances liberated, but also to some extent the identity and migration of ions, and the nature of the reactions that occur at the electrodes.

For the sake of beginners more experienced workers will pardon some of the details in the following directions for construction. The dimensions given are those of the set the author has made. The drawings are one-half size.

Weld the platinum electrodes (Fig. 1) to short pieces of heavy platinum wire (No. 22). Hold the platinum wires end to end

with 13-inch lengths of copper wire (No. 18) in the reducing zone of the blowpipe flame directed against charcoal. Stop at the instant of fusion and you will have strong joints. Cut 11.5 inch



lengths of heavy walled one-fourth inch glass tubing. Smooth the upper ends I and I'. Thread the wires through the tubes and seal the other ends over the platinum wires, leaving the joints at E and E'. Do this in a horizontal blast-flame, holding the tube in vertical position, end to be sealed down, and heating the extreme

tip only. Anneal carefully in the smoky flame. Bend the tubes over a charcoal mold to secure uniformity. Use care to get the long and short arms parallel. To protect the apparatus when in use it is well to slip short pieces of pure gum tubing over the lower part of the curves.

To hold these tubes in position use two-holed rubber stoppers sandpapered to cylindrical shape, one at FF′ and another at the top, made to fit the brass tube KK′. This tube passes through the oak piece YY′ and fits into the oak piece XX′. It is shown in perspective in figure 5; and in section in figure 6, a median section, also in figures 8 and 9, horizontal sections respectively through XX′ and YY′. If cut and bent as shown it can neither be pulled out nor rotated in the top. Observe that no glue or cement is used. This limits loss from breakage to the part broken. The two-piece oak top makes dissection for repair easy. The oak should be shellacked. The apparatus is supported on an iron stand by means of a burette clamp which grasps the brass tube. The tube serves also to protect the glass tubes from undue pressure of the clamp.

Binding-posts may be put at M and M′, but the following will save this expense and also the time and the bother of providing and looking after loose wires. Solder to the copper wires at I and I′ pieces of cotton-covered lamp cord. The author has planned to make short ones do (14 inches). Make of copper wire (No. 14) some convenient terminals for these cords. The one shown (Fig. 7) is durable, fits any binding-post, and commands the respect of pupils inclined to be careless. If city current is used this permanent attachment of the cords prevents otherwise possible short circuiting on neighboring gas and water pipes.

To make the T-tubes that slip over the electrodes the inexperienced should consult a book on glass working, as Shenstone. Good glass and proper annealing are essential. Use three-eighths inch tubing. Make the arms longer and cut to lengths shown. Do not round the ends with heat; grind them smooth with emery cloth. Attach these tubes to the sealed tubes with pieces of pure gum tubing. Wet the rubber, slip it over the sealed tube, and carefully turn the T-tube on. Figure 4 is a section through ZZ′. It shows the relative position of the tubes, and how they fit into a beaker containing the electrolyte. The T-tubes not only protect the electrodes, but by offering several paths for conductivity greatly increase the range of experimental work. See figure 3.

For gas collecting tubes procure test-tubes (6×½ inch). Etch them to show relative volumes (Fig. 2) as follows: Dip the tubes into paraffin. Cut the rings through the paraffin. Apply hydrofluoric acid solution with a camel's hair brush. The etching is rapid, and a moment's application is sufficient. The author, finding some variation in the length and bore of the tubes, paired them and etched the pairs with distinguishing numbers.

The rubber used in the construction allows slight flexibility, which lessens the danger of breakage. The pupils here have recently done a sum total of more than 400 electrolysis experiments. They have broken nothing except an occasional collecting tube and a few beakers. All of this work was done without once removing an apparatus from the burette clamp. The pupil has only to raise and lower the burette clamp on the iron stand. The tubes fill themselves when lowered into the electrolyte and empty themselves when raised. When a change of electrolyte is desired the iron stand is moved to bring the apparatus over the sink, and washing is quickly accomplished by pouring water upon and into the tubes. If electroplating has been done a few drops of acid precede the water. The use of tumblers instead of beakers is suggested.

The cost of materials for fourteen pieces of apparatus was about twelve dollars. Extra heavy platinum was used. Two-thirds of this cost represents platinum.

We use the city current, 110 volts, and a sixteen candlepower lamp for resistance with each apparatus. The requirements in these respects are about the same as for the common Hofmann apparatus.

The range of work includes, (1) collection, measurement and identification of gases liberated; (2) phenomena of electroplating; (3) substitution of other electrodes than platinum; (4) effect on conductivity of varying the concentration of the electrolyte; (5) study with indicators and other chemical means of the properties of the electrolyte within the vertical tubes (Fig. 3) and comparison with those of the electrolyte between the tubes; (6) detection by chemical means of increased or decreased concentration near the electrodes; (7) action upon each other of the secondary products formed at anode and cathode; (8) use of oxidizing agents, or depolarizers; etc.

This presentation will be followed by an article in which a suggestive list of experiments will be described, and a discussion given of the place they may occupy in a secondary course.

A GEOMETRY PUPIL'S BRILLIANT WORK.

By George W. Evans.
English High School, Boston.

The theorems appended to this article have a value in themselves as describing a little known but quite simple and important property of the plane triangle; they have also an extrinsic value as illustrating the value of a decidedly unconventional mode of attack in the teaching of geometry.

The pupil who discovered the theorems—for whatever the literature of the subject may contain, it was a discovery so far as he was concerned—had studied algebra and a little geometry before, but had taken no pleasure in them and was regarded as a very mediocre pupil. He began this year (1904-05) with a class that had had no formal geometry; not more than one or two of its forty members had any knowledge of mensuration or of observational geometry; and there was the usual difficulty of interesting them in a string of abstract theorems.

In this class we began with the area-theorems, an experiment that I do not remember to have heard of before; we proved that for the rectangle by rows of squares, and then we took the parallelogram and the triangle in the usual way. The proportional equations for equiangular triangles were made to depend upon these, the Pythagorean theorem also, and we had at once a multitude of arithmetical and algebraic applications that served the purpose of making the pupil familiar with these fundamental geometric facts.

The propositions of symmetry and concurrent lines then furnished more purely geometrical considerations, but even here the pupil was given altitudes, medians, etc., to compute, and learned to derive, among other things, the formulæ s—a, s—b, s—c, for the distances from the vertices of a triangle to the contacts of the in-circle.

And that is where this young man started. He came to me one day with the question, "Do the lines through the vertices of a triangle bisecting its perimeter meet in a point?" I did not know, and told him so. At the same time, I said I should be glad to see a proof of it, if it was so. He brought me a proof next day, with two or three different statements of the theorem, one of which was, as nearly as I can remember, the following:

The three lines formed by drawing through each vertex of a triangle a line to the contact of an escribed circle with opposite side, meet in one point.

This will rapidly be recognized as a special case of the theorem of Ceva, that if in any triangle $A\,B\,C$ three points X, Y and Z are taken upon a, b, and c, respectively, so that $AZ.\ BX.\ CY = BZ.\ CX.\ AY$, then AX, BY and CZ meet in a point. My pupil invented the orthodox proof of this theorem himself without difficulty, though he had to be scolded for the cumbrousness of the first proof that he invented on the spot. What is most unusual, however, is the consecutiveness of the boy's results, and the simple and important relation of his new point to the four familar "centres" of the triangle.

I think it proper to say that in the pupil's opinion as well as in my own his keen interest and consequent efficiency were due to the unusual order of topics and to the unscrupulous adulteration of geometry with algebra; but it is also true that his own extraordinary native ability in the subject was completely beyond the rest of the class; they were more interested in the subject than any class I ever had, but their achievements, after all, were only up to the average.

I append his proofs, in his own notation and words. He gave duplicate proofs for each, which are omitted to save space.

THEOREMS OF THE PERICENTRE.

By Chris M. Burlingame,

English High School, Boston, 1905.

The three lines drawn through the vertices of a triangle, each bisecting the perimeter, meet in a point; this point is the incenter of a triangle formed by drawing through each vertex a parallel to the base.

The line joining this point to the orthocenter of the original triangle is parallel to and twice the length of the line joining the circumcenter to the incenter.

The three lines drawn through the vertices of a triangle, each bisecting the perimeter, meet in a point.

In Figure 1, t, v, x, and w are substituted for $s-b$, $s-a$, $s-c$, and $s-b$; $CT = y$, $TA = z$.

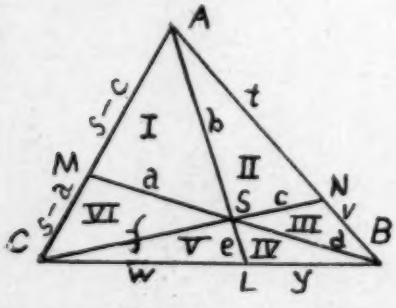


Figure 1.

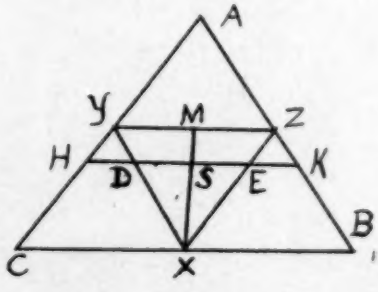


Figure 2.

In Figure 2, (1) $\frac{I}{IV} = \frac{ab}{de}$, (2) $\frac{III}{VI} = \frac{cd}{af}$, (3) $\frac{V}{II} = \frac{ef}{bc}$, (4) $\frac{I}{IV} = \frac{z}{y}$, (5) $\frac{III}{II} = \frac{v}{t}$, (6) $\frac{V}{IV} = \frac{\omega}{x}$, (7) $\frac{I}{II}\cdot\frac{III}{IV}\cdot\frac{V}{VI} = 1$ ((1)(2)(3)), (8) $\frac{I}{II}\cdot\frac{III}{IV}\cdot\frac{V}{VI} = \frac{v\,\omega\,z}{t\,y\,x}$ ((4)(5)(6)), (9) $\frac{v\,\omega\,z}{t\,x\,y} = 1$ (Substitute (7) in (8)), (10) $\frac{v\,\omega}{t\,x}\cdot\frac{MA}{CM} = 1$ (Substitute values, $s - b$, etc.), (11) $\frac{MA}{CM} = \frac{z}{y}$ ((9) and (10) $\div \frac{v\omega}{tx}$), (12) $\frac{MA}{CM} = \frac{TA}{CT}$.

This point is the incenter of a triangle formed by drawing through each vertex a parallel to the base.

In Figure 2, s is the incenter of ABC, $HK \parallel CB$, M is the intersection of lines YZ and XS. Then:—

(1) $\angle$ DSC = SCX,
(2) SCX = HCS $\therefore$
(3) DSC = HCS, $\therefore$
(4) CH = HS,
(5) CH = XE,
(6) SK = KB, $\therefore$
(7) SK = DX,
(8) DX + HS = SK + XE,
(9) HD = EK, $\therefore$
(10) DX + DS = SE + XE, $\therefore$
(11) XY + YM = MZ + ZX.

The line joining this point to the orthocenter of the original triangle is parallel to and twice the length of the line joining the circumcenter to the incenter.

In Figure 3, G is the centroid of ABC, XYZ, and X′Y′Z′; O is the orthocenter of ABC, R is the orthocenter of XYZ, and R′ is the orthocenter of X′Y′Z′; Z′Y′||YZ. If XYZ is turned around on G as a pivot, R will coincide with R′. OG is twice as long as R′G, $\therefore$ $\frac{OG}{RG} = 2$. In the same way, in Figure 4, $\frac{SG}{IG} = 2$, so that $\frac{OS}{IR} = 2$. OS ||, IR because the corresponding $\angle$s, OSG and GIR always occupy positions on opposite sides of G, making the alternate interior $\angle$s equal.

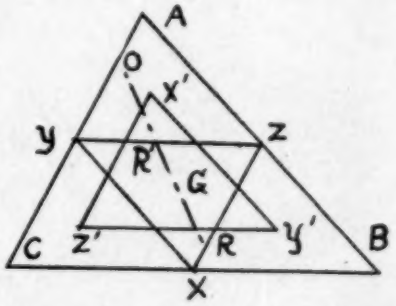


Figure 3.

Figure 5, illustrates the case of an obtuse-angled $\triangle$.

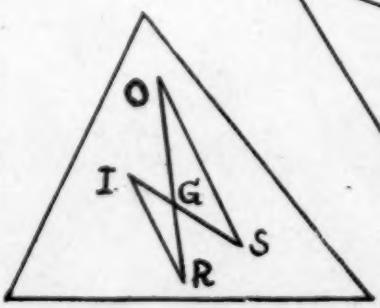


Figure 4.

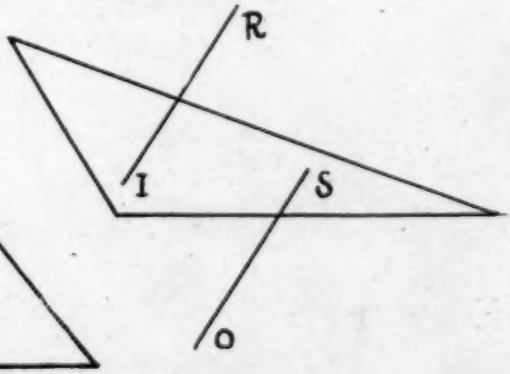


Figure 5.

A SIMPLE METHOD OF DETERMINING THE ABSOLUTE DILATATION OF MERCURY.

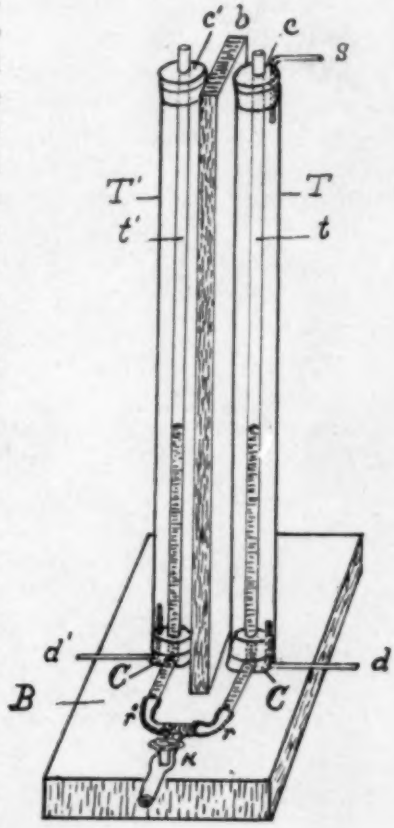
By Arthur L. Foley,
Professor of Physics in Indiana University.

It is the writer's opinion that the experiment of determining the absolute dilatation of mercury should never be attempted in the high school laboratory, and he is not convinced that it should be undertaken by first year college students. A record of the work of the larger Universities of the world shows that the experiment is not given in many of them, and of the ten per cent that do give it only a few place it in the work of the first year. However, there are a few high schools and several colleges in the United States where the experiment is given. Most of these schools use the method of equilibrating columns, and apparatus like or similar to that used by Regnault. Such apparatus is somewhat difficult to set up and take down, and in doing so the tubes are very likely to be broken and mercury wasted. Consequently the apparatus is usually fixed up once for all. The student needs only to put in the ice, turn on the steam, take a few readings and supply in a formula. He can not see "the inside of things" and he may really know little or nothing about the fundamentals of the method.

The apparatus proposed in this paper is much simpler than that used by Regnault or Dulong and Petit, and in the hands of the beginner is just as likely to give satisfactory results. A simple form of the apparatus is shown in the accompanying figure. To a heavy wooden base (B) is fastened in a perpendicular position a board (b) about a meter long. This board serves a double purpose. It supports the two glass tubes for the mercury columns (or their jackets), and it acts as a screen to prevent heat passing from one to the other. A glass tube (t) of whatever length is desired, is bent at right angles about 15 cm. from its lower end and connected by means of a rubber tube (r) to a similar glass tube (t′) on the other side of the board (b). It is very convenient to have a stopcock (k) connected by the rubber tubes (r) and (r′) to (t) and (t′), so that mercury can be drawn from the tubes without disturbing the apparatus. The rubber connecting tubes would be objectionable were the highest degree of accuracy sought for; but where the apparatus is in the hands of the inexperienced they are almost a necessity. Where

the tubes (t) and (t′) are welded together or made from a single piece of glass, considerable care is necessary in supporting them so that they shall at all times be free from mechanical strain; and the apparatus is troublesome to take down and clean.

A glass tube (T) of a larger diameter serves as a jacket for the steam which enters through a tube (s) passing through the cork (c). The cork (C) at the lower end of the tube is cut away as shown; (d) is a drip to drain the jacket of condensed steam. The tube (t′) on the other side of the board may be jacketed in the same way, and instead of passing steam through this jacket (d′) may be connected to a water tap, and the jacket supplied with running water. Or the jacket may be filled with ice. In packing the ice in the jacket it must be remembered that the end of the mercury column must be kept in sight. It will answer fairly well to use only large pieces of ice on the side of the jacket next the cathetometer, which is used to measure the heights of the mercury columns. A better way is to make out of a strip of tin a sort of collar or cylinder with open ends, and of such a length that it will drop in between the mercury column and the jacket and give a small space free of ice. Several of these can be placed in the jacket at points where it is desired to make a measurement. Very good results may be obtained by entirely dispensing with the jacket on the left and leaving the mercury column exposed to the air, and taking its temperature with a thermometer held against the column with rubber bands.



The method is very simple. Into one of the tubes, say (t') is poured a quantity of mercury sufficient to stand several centemeters high in each arm. After the lapse of a sufficient time to permit the two mercury columns to assume the temperature of their baths their hights are carefully measured by means of a cathetometer. More mercury is then poured in the tubes and under the same temperature conditions as before, the hights of the columns are again measured. The difference in the hights before and after adding the mercury together with the temperature difference of the two arms, are all the data required. Many independent readings may be made by adding or removing mercury, or changing the temperature of the baths.

Regnault found that the coefficient of expansión of mercury increased with the temperature and could be approximately expressed by the equation

$$c=a+bt$$

where a and b are constants and t the temperature. He found that the value of b is so small that for temperatures between 0°C and 100°C the term involving it may be neglected, and the coefficient considered constant. Assuming this to be true and calling h_t and h_t' the difference in the hights (before and after adding mercury) of the mercury columns at temperatures t and t' respectively.

$$h_t = h_o(1 + a\,t)$$
$$h_t' = h_o(1 + a\,t')$$

where h_o is the difference in the hights at a temperature of 0°C; that is, the length at 0° of the added mercury column.

Eliminating h_o and solving for a,

$$a = \frac{h_t' - h_t}{h_t\,t' - h_t'\,t}$$

Where the temperature $t=0$

$$a = \frac{h_t' - h_o}{h_o t'}$$

Using the method described and the last equation, a value of the coefficient a can be obtained by any reasonably careful observer which is in error by less than one half of one per cent. If long mercury columns are used, so as to give larger values of ht and ht'. the error can be made still less. Indeed, one may, where no cathetometer is available, determine the value of h_t and h_t' with ordinary meter sticks, placing one in each of the jackets and holding it against the mercury columns with rubber bands. If

hights are estimated to tenths of a millimeter and long mercury columns are used, the method will give results in error by less than three per cent.

It will be observed that the method above outlined is free from several sources of error more or less troublesome in the methods of Regnault, and Dulong and Petit. There are no portions of the mercury column (the part to be measured) exposed so that the temperature can not be constant throughout, and the hights of the columns are not measured from some assumed point of equilibrium in a horizontal connecting tube. There can be no trouble from convection currents, and surface tension troubles are completely eliminated. The latter fact enables one to use a tube of small bore, and therefore, a relatively small quantity of mercury, though the tube be made as long as desired. A small column comes to the temperature of the enclosure more rapidly than one of larger diameter. In short, many sources of errors are eliminated, and but one, that I think of is introduced. This is the error due to viewing the column through the glass walls of the jacket. This error is not so serious as it would appear at first thought. If the jacket walls are reasonably true, and not very thick, the error in any case is not large, and it can be partially corrected by turning the jacket about its axis and viewing the mercury column through different portions of the glass wall. The error is still further reduced by taking measurements of the mercury column at several different heights. To increase the accuracy of the method one may replace the glass jackets with metal jackets provided with a number of small windows up and down the tube. These windows can be covered with very thin microscope coverglass or sheets of mica, and the mercury column can be viewed through the window. Results obtained by this method will be published later.

PROPOSED AMENDMENT TO C. A. OF S. AND M. T.

Central Association of Science and Mathematics Teachers, Proposed Amendment to the Constitution. **To amend Article X and Amendment I by substituting "one dollar and twenty-five cents" for "one dollar" wherever used in connection with "School Science" and "official organ."**

THE TREATMENT OF ENERGY IN MECHANICS AND HEAT.

By S. E. Coleman,

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There are two fundamentally different points of view from which the subject of energy may be approached. In one case the idea of energy is treated as primary, and the idea of force is derived from it. In the other case the order of these ideas is reversed, force being regarded as the primary and energy the derived idea. Historically, we know, the concept of force preceded that of energy. On the other hand, the concept of energy now occupies the central position in natural science. It is the concept which, more than any other, constitutes the bond of union between the otherwise loosely related branches of scientific knowledge. Neither of these facts, however, can be held to settle the question which point of view is the better for the purposes of elementary instruction. This is a pedagogical question, not an historical or a purely logical one, and can be answered only by considering which point of view affords the easier and more successful approach to definite conceptions concerning forces and forms of energy and their relations to one another.

The method which makes energy the starting point has some able advocates; although, so far as the evidence afforded by textbooks is concerned, they seem to be in a very small minority. This method is adopted in Prof. Sanford's "Elements of Physics" and in Appleton's "School Physics." Prof. Slate's Physics may be added to the number; but contains little that serves to classify it with reference to the present question. I shall assume that it is fair to judge of the merits of this point of view from the success with which the subjects of force and energy are presented in these books, for, on the whole, they all rank high in point of accuracy. Prof. Sanford's book begins with the subject of work and energy, studied experimentally by means of the simple machines. Energy is provisionally defined at the outset as "the capacity for doing work." In the discussion of machines the word force is not used; and the idea of force (expressed by such words as effort, power, pressure, and friction) is avoided as much as possible. This treatment, it seems to me, is conspicuously deficient in clearness and definiteness, and can only add to the confusion of the ideas of force and energy that

inevitably exists in the mind of the beginner. That this is so will at once be evident from the following quotations, in which the substitution of the word force for energy leaves the statements equally correct and more in accord with customary usage. "A machine," to quote from the book, "is an instrument in which energy is applied in the performance of work." "The arm (of a lever) to which the energy is applied to do the work is called the power arm." "Since both the weight and the energy which moves it may act on the same side of the fulcrum, the same part of the lever," etc.

Further, this method of treatment leads to a narrow and essentially inaccurate presentation of the ideas of work and energy, aside from the confusion of energy with force. Energy, as already stated, is defined as the capacity for doing work. The idea of energy can therefore be no more accurate in the mind of the pupil than that of work, and, in all probability, will be less accurate from its confusion with force. Now the discussion of work is extremely narrow, being limited to work done against weight; and is open to misconception even on this point. Quoting again, "The term work, as used in physics, may be defined as the producing of such changes in the relative positions or relative motions of material bodies as would require an effort on our part to produce. Thus we do work upon a stone when we lift it from the ground or when we throw it." But it also requires an effort on our part to carry a weight at a uniform rate over level ground, and the pupil would undoubtedly think that this involves the doing of work upon the stone as the term is here defined; but no work is done upon the stone. Again, a constant effort is required to keep a body revolving with uniform speed in a circle at the end of a string, but no work is done upon the body.

In Appleton's Physics the subject of energy is taken up after a brief discussion of certain preliminary ideas (not including force) and a systematic treatment of kinematics. Energy thus stands practically at the beginning of the subject of physics in this book, kinematics being merely a branch of pure mathematics. Here also energy is defined as the capacity for doing work, and work is thus defined: "A body is performing work whenever, and as long as, it is causing acceleration of any other portion of matter," and again, "Whenever a particle of matter is being accelerated, work is being done upon it by some other portion

of matter possessing energy." We have here a repetition of the error noted in Prof. Sanford's book. Change of direction without change of speed always involves acceleration, but never a transference of energy or the doing of work.

Not only do we find the treatment of energy before a consideration of forces unsatisfactory and open to serious criticism (and I believe necessarily so), but the idea of force also fares no better when presented as growing out of the idea of energy. Prof. Sanford in defining force quotes Newton as follows: "Impressed force is action exercised on a body so as to change its state of rest or of uniform motion in a straight line," and adds: "Expressed in the language we have been using, a force is whatever produces an acceleration." According to these definitions, forces in equilibrium are not forces at all. According to Appleton's, "Force is any tendency to acceleration." As well describe an ass as a tendency to bray. No very definite or serviceable information is conveyed in either statement. In Appleton's the systematic treatment of the usual topics in mechanics is taken up after the presentation of the idea of force; and, with a few minor exceptions, this treatment is from the point of view of force, not energy. In my opinion, little or nothing is gained by starting with the idea of energy, certainly nothing that outweighs the serious objections to this plan.

The treatment of dynamics in Prof. Slate's Physics is so meager that little can be gained from it for the purpose of our present discussion. One quotation will serve as a further illustration of the difficulties attending this point of view. "We shall measure work," says this text, "by multiplying together force and distance moved along its line." The very phraseology of this statement implies that the rule is purely arbitrary; and there is nothing in the discussion of it that even remotely suggests that to measure the displacement along the line of the force is anything else than an arbitrary choice. Moreover, I see no possibility of stating the reason except in terms involving a previous consideration of forces and their effects.

These criticisms indicate some of the principal objections to the point of view which makes energy the primary idea. The inherent difficulties of this point of view are apparently such as to make a satisfactory presentation of it impossible. By starting with force as the primary concept, the subject of mechanics, it

seems to me, can be and generally is made more simple, definite, and coherent; and the importance of the idea of energy need not be in the least obscured by so doing.

The order of topics in mechanics that I prefer is as follows: (1) Various introductory ideas, including a preliminary treatment of forces, both balanced and unbalanced. (2) The mechanics of liquids and gases. (3) The statics of solids. This includes the equilibrium of concurrent and parallel forces, moments of force, and the effect of weight on the equilibrium of bodies. (4) Dynamics, including motion, falling bodies, projectiles, the laws of motion, curvilinear motion, gravitation, and the pendulum. (5) Energy, work, and the simple machines. This arrangement presents the serious difficulties of mechanics gradually, and, it seems to me, in the easiest order. I am following essentially this order in my classes with Carhart and Chute as a text. While there is always more or less trouble in departing from the order of the text book, I believe the advantages gained in this instance more than outweigh the disadvantages. In the treatment of the mechanics of fluids and the statics of solids without reference to energy little of value, if anything, is omitted. None of the books referred to at the beginning of this paper make any important use of the idea of energy in the presentation of these subjects. There is, as we have seen, a more clearly defined difference of opinion as to the advisability of deferring all consideration of energy until after the systematic study of unbalanced forces (dynamics). I shall therefore undertake to show how the difficulties encountered when energy is considered first may be avoided when the opposite course is pursued. The latter plan is adopted in Carhart and Chute, the subject of work and energy coming at the end of the chapter on the mechanics of solids.

I am not advocating that all mention of energy should be avoided during the study of unbalanced forces. Energy will inevitably demand some attention through the pupil's confusion of it with force. For example, a pupil may say that a swiftly flying ball moves through the air *with greater force* than one moving more slowly. I would correct the error in some such words as these: "A ball does not move through the air with force at all. The force that imparts motion to the ball (as the sudden pressure of a bat) ceases to exist when the ball begins its free

flight. The moving ball is able to exert a force (pressure) when it meets with any body opposing its motion (as the hands of a player in the act of catching it). The ball is, of course, exerting a force against the air throughout its flight; but this is commonly disregarded, and is evidently not what you have in mind when you say the ball is moving with force. The moving ball does possess something that the ball at rest does not, and we call that something energy. It is imparted to the ball by means of the force that sets it going, and is given up by the ball in exerting a force on whatever stops it." I do not try to avoid such anticipations as these in a recitation. They are distinctly serviceable in making the approach to new topics less difficult. In this instance the pupil understands that the definite word with reference to energy remains to be said; and he has grasped the important fact that energy is not force, although having a definite connection with it.

A conspicuous defect of the customary treatment of work and energy is that it is extremely narrow and incomplete without appearing to the beginner to be so. Is not even the inexperienced teacher sometimes misled by the air of finality with which fragmentary truths are often presented? In Carhart and Chute, for example, the only forms of potential energy mentioned in the section on Work and Energy are energy of position relative to the earth and energy due to the relative positions of the parts of a body; heat is mentioned in only one brief sentence; and the only transformations of energy considered are that of kinetic energy into energy of position and the reverse, together with an incomplete statement of the dissipation of the energy of a watch spring in running the watch. There is not even a suggestion as to what becomes of the kinetic energy that disappears in overcoming friction. There is no attempt at a distinction between work done in changing kinetic energy and work done against weight or friction; and the pupil is consequently left wholly in doubt in regard to the relation between work and kinetic energy. Equipped with such fragmentary information as this, how much meaning can the pupil read into the half page discussion of the principle of the conservation of energy with which the section on work and energy is concluded?

It is customary at the beginning of the subject of work and energy to define work more or less definitely as the product of force and distance, and to define energy as the capacity for

doing work. You are all doubtless familiar with the complacent assurance with which the average pupil repeats this definition of energy. Have you ever considered how much, or rather, how little it means to him? I doubt whether it ever conveys a definite meaning to the pupil, and it certainly never conveys a complete and accurate one. Generally, I believe, it conveys no meaning at all. It has the further disadvantage of being easily remembered. After the pupil has once read it, he naturally supposes that he has nothing more to learn concerning the nature of energy; for the average pupil readily accepts words as a substitute for ideas. What is the thought that is concealed in the statement, rather than expressed by it? Stated simply, it is merely this: That a body possessing energy can (under certain conditions) set other bodies in motion. This teaches us to rec ognize the presence of energy through certain of its manifestations, but does not tell us what energy is. *It is not a definition of energy.* Why present it as such? Why present it at all? The proper starting point in the whole subject is a simple discussion of the familiar forms in which energy exists and the familiar ways in which it manifests itself to the senses. It is quite as futile to try to formulate a real or a useful definition of energy as it is to try to define matter. We can define the kinds of energy (at least some of them) and also the states of matter; but matter and energy are incapable of definition. True ideas of either must be obtained, not from formal statements presented as definitions, but from a study of the various forms of matter or of energy.

Having developed the idea of energy by means of familiar illustrations, work may then be defined as the transference of energy from one body to another. The amount of energy transferred and the amount of work done are, according to this definition, equivalent expressions. This, it seems to me, presents the relation between energy and work in the simplest and most serviceable way, and is the logical starting point from which to develop the rule for the numerical measure of work. The development of the rule from the definition involves a consideration of the conditions necessary for the transference of energy or the doing of work,—a topic that is very inadequately presented in most elementary texts, notwithstanding its fundamental importance. It may therefore be worth while to consider this topic in

detail as it might be presented to a class, starting with the definition of work just given.

Although work is done only through the action of force, a force may act without doing work. When a horse pulls upon a load without starting it, no work is done by the force exerted, for there is no transference of energy to the load. If the load is started, the force acts through a certain distance, and, in doing so, does *work of acceleration* in imparting kinetic energy to the load and *work against resistance* in overcoming friction. (Friction, it should be noted, develops heat, and heat is a form of energy; hence to maintain motion against friction involves the transference of energy, or the doing of work.) There is neither work of acceleration nor work against resistance without motion of the body upon which the force acts. A force may also act upon a moving body without doing work. Whether work will be done or not depends upon the relative directions of the force and the motion, as will be seen from the following illustrations. The weight of a projectile rising vertically diminishes its kinetic energy by doing negative work of acceleration. The weight of a falling body does positive work of acceleration upon it, constantly increasing its kinetic energy. In both cases the line of action of the force (weight) is parallel to the direction of motion. As a pendulum vibrates, it is only the tangential component of the weight of its bob that does work of acceleration, causing gain of kinetic energy during the first half of each vibration and loss of kinetic energy during the second half; and it is only this component that does work against the resistance of the air. The other component of weight, which acts at right angles to the direction of motion, does no work, for it neither changes the speed of the bob nor helps to maintain its motion against the friction of the air. The same is true of the tension of the thread. A force acting upon any body at right angles to its direction of motion does no work; for it neither changes the speed of the body nor helps to maintain its motion against friction or other resistance. This is true whether the force is balanced or unbalanced. The centripetal force in circular motion does no work, although unbalanced. Thus, on the whole, no work is done upon the moon by the attraction of the earth, or upon the planets by the attraction of the sun. In the case of oblique forces, such as the weight of a pendulum bob, it is only the

tangential component of the force that does work; that is, the component whose line of action is parallel to the direction of motion.

If the pupil is to acquire clear and adequate conceptions of the relations of force, work, and energy, it must be through some such discussions as these of examples of motion already familiar in detail from the previous study of falling bodies, curvilinear motion, the pendulum, etc.

Heat as a form of energy is a topic that should not be neglected as it commonly is in this general introduction to the subject of energy. The quantitative treatment of the topic belongs, of course, to the chapter on heat; and the kinetic theory of heat should also be left for later consideration. It is sufficient to recognize heat as one of the many forms in which energy exists, without raising the question what that form really is. The following facts and illustrations indicate the ground that may very profitably be covered here. When work is done upon a body to maintain its motion against friction, there is no increase of kinetic energy, but heat is developed; and the energy that appears in this form is the equivalent of the work done. Whenever one surface moves upon another, heat is developed by the friction between them; but often so slowly that it is dissipated before there is appreciable rise of temperature, and we fail to notice it. With rough surfaces and rapid motion, however, the rise of temperature is often considerable. For example, a match is ignited by the heat generated in striking it; and a piece of metal becomes very hot when ground upon a dry grindstone. When a cord or a rope that is grasped tightly is drawn rapidly through the hands, sufficient heat is often developed to cause a burn. The friction by which a body is stopped changes or transforms the kinetic energy of the body into heat at the same time. This is why the brakes of bicycles, carriages, and cars become hot when in use. I am sure that the usefulness of these ideas at this point will hardly be questioned by any one. Without them the discussion of even the simplest phenomena from the point of view of energy is in most cases incomplete.

It seems to me desirable that the introductory treatment of energy under the subject of mechanics should be broad enough to include a recognition of all the familiar forms of energy. The mere mention of electrical energy is sufficient to bring to the

mind of the average boy many instances of its manifestation. The chemical potential energy in fuel of all kinds should be briefly commented upon, and its familiar transformation into kinetic energy by means of the different kinds of engines called to mind. Muscular energy is a matter of immediate interest, and should be recognized as a form of potential energy,—chemical potential energy, in fact; for muscular energy is available for doing work only through chemical changes by which the muscles are in part consumed, much as fuel is consumed in a fire. To recognize the source of muscular energy in the food eaten is instructive. The purpose of all this is not to teach new facts concerning the things talked about, but to help the pupil to an adequate conception of energy.

If the introductory treatment of energy is broadened along the lines suggested, the pupil will be in a position to attach some meaning to the principle of the conservation of energy; but, even it is much better to take up this topic at the end of the chapter on heat, after teaching Joule's equivalent. The pupil is then in possession of quantitative ideas concerning the transference of mechanical energy by means of the simple machines, the transference of heat in calorimetry, and the transformation of mechanical energy into heat. Having thus become familiar with energy as a measurable quantity in certain cases, there is a reasonable probability that the pupil may be able to grasp the idea of the equivalence of energy in all its transformations. If an attempt is made to teach the conservation of energy as a general principle before such preparation, the pupil should not be expected to receive it as anything more than a nearly meaningless dogma.

The simple machines may be studied as devices for the transference of energy from one body to another in two ways, representing exactly opposite points of view. In one the principle of the conservation of energy is *assumed;* and, assuming further that the machines are ideally perfect, this gives the general law of machines that "the effort multiplied by the distance through which it acts is equal to the resistance multiplied by the distance through which it is moved." This law is taken as the starting point from which the mechanical advantage of each of the simple machines is deduced. This is the method of treatment adopted in Carhart and Chute and in Appleton's.

The other method proceeds as follows: (1) The ratio of the

resistance to the effort is found, either experimentally or by reasoning from known relations, to be equal to the ratio of two dimensions of the machine. For example, with the lever it is the ratio of the arms, taken inversely, or W : f : : a : A. This gives the mechanical advantage of the machine, determined from the point of view of the equilibrium of forces. (2) The ratio of the distance through which the effort acts to the distance through which the resistance is moved is proved, either mathematically or experimentally, to be equal to the ratio of the same two dimensions of the machine. Thus for the lever d : D :: a : A. (3) The conservation of energy by the machine is proved by combining the results of the first and second steps. Thus, from the above proportions for the lever, W : f :: d : D, or WD = fd. The equations obtained for a combination of fixed and movable pulleys having n parts of the cord supporting the movable block are as follows: (1) f=W÷n, (2) d=D×n, (3) fd=WD.

Hoadley and Avery derive the mechanical advantage of the simple machines by this method, but carry the discussion no further than this. They both state the general law of machines at the beginning of the subject, but make no use of it.

These two methods of presenting the subject of machines are about equally simple; but are unquestionably of very unequal merit. The first proceeds from a principle dogmatically asserted and accepted on faith,—a most unsubstantial basis for real knowledge. The second presents a quantitative experimental basis for the understanding and acceptance of that principle; for, by this method, the pupil proves that, with 100 per cent efficiency, the work done by a simple machine is no more than equal to the work done upon it; that is, even under ideally perfect conditions, the machine creates no energy.

We now come to the treatment of energy in the subject of heat. Doubtless the subject of heat can be well taught without assuming a theoretical point of view at all, *i. e.*, without raising the question what the form of energy that we call heat really is. That it is energy in some form is not a theory but an established fact. Practically this is all that the average elementary text does, in spite of the brief article on the theory of heat that is placed at the beginning of the subject. It is one thing to present the kinetic theory of heat in from six to ten or a dozen lines, from which the pupil may gather a few high sounding phrases

about molecular vibration and molecular energy, and quite a different one to present the matter in such a way as to impart the appropriate ideas. The first is not worth doing; no piece of sham work ever is. The second is worth doing, if the teacher chooses to take the time necessary for it. It is first of all necessary to lay the foundation for the theory in the experimental and descriptive study of the structure o fmatter. This includes: the divisibility of matter, leading to the idea of the molecule; porosity, presenting the idea of spaces between the molecules; compressibility as evidence of the porosity of all matter; and expansion due to heat, accounted for by supposing that the molecules become more widely separated. This is followed by experiments on the diffusion of gases and liquids, which is explained upon the supposition that the individual molecules are in motion, and by the further application of this idea in explaining the pressure and expansibility of gases. The kinetic theory of heat is next in order. According to this theory, when a gas is heated the velocity of its molecules is increased. This explains the expansion of gases when heated, or, if expansion is prevented, the increase of pressure. Further evidence that heat increases molecular motion is found in the increased rate of diffusion of liquids and gases when heated. The expansion of liquids and solids when heated is also attributed to increase of molecular motion. The more energetic vibration of the molecules enables them to push their neighbors farther away, and the whole mass expands in consequence. This molecular pressure due to heat opposes cohesion, which tends to bring the molecules into permanent contact. It is the mutual relation between cohesion and molecular pressure which determines whether a substance will be in the solid, liquid, or gaseous state. In solids, cohesion greatly predominates, and the molecules hold together, or cohere, in fixed relative positions. The same is true of liquids, but in a less degree; the molecules cohere, but are able to wander at random among one another. In gases at ordinary pressures and temperatures the molecules are so widely separated that attraction is inappreciable or wholly wanting, and molecular pressure is balanced only by external force.

If the teacher makes a serious attempt to form the pupil's ideas on the theoretical side of the subject, as here indicated, he will discuss the transformation of heat into molecular potential energy

in the process of fusion and vaporization, and will distinguish sharply between heat and radiant energy. At the least it should be recognized that a definite amount of heat ceases to be heat and becomes some other form of energy when fusion or vaporization takes place, and that this energy is recovered as heat when the reverse change of state occurs. The terms "latent heat" and "radiant heat" should be banished from the text book and the recitation. They are misnomers, and only lead to confusion. There is only one kind of heat and that is plain heat, without a qualifying label of any sort. In the words of Professor Smith of Chicago University, only substituting the word physics for chemistry, "Our ideas in physics are so often labeled wrongly that we must discredit the label while teaching the idea; our terms often obliterate the very distinctions they are intended to record." Witness further that worst of misnomers, "centrifugal force," as the term is commonly used; which even the more careful writers define in one sense and use in another, to the utter confusion of the whole matter.

The pupil will, of course, become acquainted with the quantitative idea of heat through the experiments in calorimetry. This prepares the way for the discussion of the mechanical equivalent of heat and the principle of the conservation of energy, as before remarked. The teacher misses a rare opportunity at this point if he does not say a few words on the ultimate source of the energy that does the work of the world and is manifested in nearly all terrestrial phenomena. With whatever manifestation of energy we may start, excepting only the tides and a few due to the heat of the interior of the earth, we can trace that energy back to solar radiation. Even the mental energy that you have expended in giving attention to the ideas presented in this paper had its ultimate source in the sun. The study of the steam engine should, of course, include a consideration of the transformation of energy affected by it.

In conclusion I wish to add what I hope has been clearly indicated throughout the paper; namely this, that our physics teaching should be less fragmentary and dogmatic, more coherent and reasonable, and that the idea of energy may be largely utilized to make it so.

THE TREATMENT OF ENERGY IN MECHANICS.

DISCUSSION OF PROFESSOR S. E. COLEMAN'S PAPER.

By Fernando Sanford.

Professor of Physics at Leland Stanford University.

In attempting to discuss the very interesting paper to which we have just listened, I am put somewhat on the defensive from the fact that the writer seems to have prepared his paper largely as a criticism of the method of presenting the subject of mechanics in my unfortunate text-book. Before attempting to reply, I wish to thank Mr. Coleman for his very frank and courteous criticism. I shall try to be equally frank, and I hope I shall say nothing which can be construed as discourteous.

With Mr. Coleman's aim we are all in the most hearty sympathy, and I should like to quote with special approval his closing sentence, viz.: "Our physics teaching should be less fragmentary and dogmatic, more coherent and reasonable, and the idea of energy may be largely utilized to make it so." I should even like to emphasize this statement still more. The study of physics, which is essentially the study of energy transformations, can be made coherent and reasonable only by keeping the energy idea uppermost in our minds. It is not merely the most important idea in modern physics, it is in a sense the whole of modern physics. Mechanics is essentially the study of energy transference involved in the various motions of bodies of sensible magnitude and of energy transformation from potential to kinetic and *vice versa*. Heat is a study of energy transference involved in movements of molecules and atoms, and Electricity, Magnetism, and Optics are largely the studies of energy transference by means of the luminiferous ether. The same thing is true to almost the same extent in modern chemistry, which has come to be largely the recognition and measurement of the energy changes involved in chemical reactions.

Now the paper under discussion argues that we may best arrive at an understanding of energy and its changes by deriving the idea of energy from the notion of force. This assumes that the idea of energy is involved in the notion of force and can be derived from it. This, it seems to me, is a mistake. Not only is the idea of energy not involved in the doctrine of force, but it is absolutely contradictory to that doctrine as it was originally held, and it took fifty years after Rumford had shown how work could

be measured in terms of heat before the independent existence and the indestructibility of energy were recognized. This was principally because it was believed that physical phenomena were in some way caused by immaterial forces acting between material bodies. When energy was finally recognized, it was seen that there was no such thing in the physical universe as *a force* in the sense in which the term had always been used. The term force continued to be used in physics and to be defined as it always had been; but it was seen that what had before been regarded as a cause of phenomena was only the quantitative expression of the rate per foot or per centimeter at which the body under consideration was gaining or losing energy.

There are a good many more terms in use in physics which have lost their original meaning. The term ray in Optics used to mean the path of a projectile; it now means a radius of the spherical wave by means of which radiant energy is propagated. A refractive index used to mean the ratio of the sines of two angles; it now means the ratio of two velocities. The definition is still the same, but the content of the notion is very different.

In the text-book which has been referred to in the paper, the attempt was made to begin the subject of mechanics by considering some of the simplest energy transformations, and to show how the simple machines are adapted for transferring the kinetic energy of one body to another and for transforming the potential energy of gravitation into the kinetic energy of moving bodies. According to the paper, "The method of treatment leads to a narrow and essentially inaccurate presentation of the ideas of work and energy, aside from the confusion of energy with force." Here I must express my conviction that the author is wrong. Narrow, the idea of energy must be, for only a narrow idea of energy can be derived from the study of elementary mechanics alone, but inaccurate it is not. So far as it goes it is accurate. Later the ideas of work and energy are broadened in the study of heat, of electricity and magnetism, and of radiation. The statement that "the discussion of work is extremely narrow, being limited to the discussion of work done against weight," seems intended to give the impression that work is nowhere discussed except in the first ten or twelve pages of the topic of mechanics. This is not the case. The energy idea is the predominant idea in the whole book. Neither is it true that the

idea of energy is anywhere confused with the idea of force, as it seems to be confused throughout the paper under discussion. In fact, the writer objects to the book because, "In the discussion of machines the word force is not used, and the idea of force (expressed by such words as effort, power, pressure, and friction) is avoided as much as possible." I hope it is avoided altogether. I should be very sorry to know that I had tried to express the idea of force by some of these words, either in the discussion of machines or elsewhere.

And here allow me to observe that I have tried very hard but unsuccessfully to find out what Mr. Coleman means by the term force. He rejects the definition which has been used by the standard writers on mechanics for 250 years, but he does not tell us what new definition he has invented to take its place. In his criticism of the definition as given in the three books he mentions, he says, "Professor Sanford in defining force quotes Newton as follows: 'Impressed force is action exercised on a body so as to change its state of rest or of uniform motion in a straight line.'" Then referring to the definition derived from this, viz.: "A force is whatever produces an acceleration," he says, "According to these definitions, forces in equilibrium are not forces at all." This is not a new discovery on Mr. Coleman's part. Dr. Thomas Young's Treatise on Natural Philosophy, published 100 years ago, says (Vol. I, p. 26), "It is a necessary condition in the definition of force, that it be the cause of a change of motion with respect to quiescent space."

One principal cause of confusion in the paper under discussion seems to me to be the writer's inability to separate the qualitative and quantitative notions of force. While Galileo seems to have been the first to attribute physical phenomena to forces which could act between bodies not in actual contact with each other or in mutual contact with any intervening medium, no qualitative or quantitative definition of force was agreed upon until Newton's time. Newton gives a qualitative definition of force in the Principia, Book I, Def. IV, as follows: "Force is an action exerted upon a body in order to change either its state of rest or of uniform motion in a straight line." This definition of force became the accepted definition of the world. When a man says force, this is what he should mean, not effort, nor power, nor friction, all of which generally mean something else.

The quantitative definition of force accepted throughout the world is also due to Newton, and is given in his second law of motion, viz: "Change of motion is proportional to the impressed force and takes place in the direction of the straight line in which the force acts." Newton has prefaced this definition by a definition of quantity of motion, viz: "Quantity of motion or the momentum of a rigid body moving without rotation is proportional to its mass and its velocity." Hence, change of motion, as Newton has used the term, means change of momentum. Change of momentum has come to be called acceleration. Hence a force is, qualitatively, whatever produces an acceleration. Quantitatively, it is the product of the mass into the acceleration and is expressed by the equation, Force equals Mass times Acceleration.

Returning to Newton's qualitative definition, he says, "Force is an action exerted upon a body" etc. Further than this he was unable to define it, for in his day a force was regarded as something independent of mechanical conditions and hence incapable of mechanical definition. Now we know that the only action by which the state of rest or of uniform motion in a straight line may be changed consists in the transference of energy to or from the body under consideration. In this way, and in no other, may a body receive an acceleration. Mr. Coleman objects to this definition of force on the ground that it leaves out of consideration what he calls forces in equilibrium. Qualitatively it does not necessarily leave them out, for if a body is acquiring and losing energy at the same rate it may be said (if anything is gained thereby) to have two equal and opposite forces acting upon it, but quantitatively, the resultant of all the forces acting upon it is zero. In this connection, allow me to call attention to the criticism of Prof. Slate's statement of the relation between force and work, that is, that work may be measured by multiplying together force and distance moved along its line. Mr. Coleman says, "The very phraseology of this statement implies that the rule is purely arbitrary." Let us see if this is true. From the quantitative definition of force, a body acted upon by a constant force has uniform acceleration, that is, it is gaining or losing momentum at a uniform rate per second. But we know by experiment that when a body is gaining or losing momentum at a uniform rate per second, it is gaining or losing kinetic energy at a uniform rate per foot or per centimeter. The momentum of a falling

body is proportional to the time it has been falling. The kinetic energy of a falling body is proportional to the distance through which it has fallen. Hence, force which is quantitatively expressed by the equation, Force equals Mass times Acceleration, may also be expressed by the equations Force equals Momentum divided by Time and Force equals Energy divided by Space.

What then is force? Qualitatively, it is a transference of energy from one portion of the physical universe to another portion. But this is the definition of work proposed in the paper. In this instance, at least, the writer seems to have hopelessly mixed his labels. Qualitatively, force is the *time rate* at which a body gains or loses momentum, or the *space rate* at which a body gains or loses kinetic energy. It is not in any sense a part of the physical universe. It is not an objective existence. Energy, on the other hand, is an indestructible part of the physical universe. It is bought and sold on the market all the time. In one form or another we pay most of our income for it. It is not an idea derived from the notion of force, but an actual physical existence which had to be discovered by expereiment.

And now a few words about the qualitative definition of energy to which Mr. Coleman objects, viz.: "Energy is the capacity for doing work." As you probably know, I am not responsible for this definition. Maxwell (Matter and Motion, p. 59) says, "Energy is the capacity for doing work." The Encyclopedia Brittanica says, "Energy may be defined as the power of doing work or of overcoming resistance." The Standard Dictionary says, "Energy—Capacity for performing mechanical work." Surely, my unfortunate text-book should not be criticised for using this definition. Personally, I know of no other.

And right here allow me to call attention to another case where Mr. Coleman proposes to voluntarily introduce confusion into his discussion of energy by introducing the term mental energy. He says he would tell the pupils directly that the so called energy employed in apprehending a discussion like the present one is directly correlated with the energy of radiation and of chemical reaction. Possibly this is true. No one knows whether it is or not. So far, no one has even proposed a unit by which mental energy can be measured, to say nothing of devising a method for measuring the mechanical energy transformed into mental energy in the simplest possible mental process. Mr. Coleman has ob-

jected to dogmatic teaching, but nothing can be more dogmatic than a statement of the kind with which Mr. Coleman tells us he interests his classes in the subject of energy.

In conclusion, allow me to return for a moment to Mr. Coleman's definition of work, viz.: "Work is the transference of energy from one body to another." Let us see what kind of a clear cut mental image this definition will lead to. Energy is the capacity for doing work. Work is the transference of energy from one body to another. Therefore, Energy is the capacity for the transference of energy from one body to another. And yet Mr. Coleman has tried to make us believe that "if the pupil is to acquire clear and adequate conceptions of the relations of force, work, and energy, it must be through some such discussions as these."

SOME AGRICULTURAL PRODUCTS OF THE TROPICS.

By Mel T. Cook.

Chief of the Department of Plant Pathology, Cuban Agricultural Experiment Station.

1. Sugar Cane.

It is interesting to know that we are more indebted to the Gramineae than to any other family of the plant kingdom for our food supply. Corn, wheat, oats, rye, barley, rice, grazing grasses for our domestic animals, and sugar cane, concerning which we wish to call your attention at this time, all belong to this family.

Sugar cane has been cultivated from time immemorial, in fact so much earlier than authentic history that we do not know the original home of the plant, but it is supposed to be of Asiatic origin. There are twelve species of the tropical genus Saccharum, most of which belong to the eastern hemisphere. The most important is the true sugar cane, *Saccharum officinarum Linn*, which grows from 8 to 20 feet in height and is now cultivated throughout the tropical world wherever the conditions will permit. It was first cultivated extensively in the country lying between Cochin China and China in Bengal and the art of sugar boiling was known as early as the 7th century. The spread of the growing and manufacture of sugar was due largely to the Arabs and at about the period of the discovery of America, Spain, then in the height of her glory, was giving considerable attention to it. In 1494 she carried the first sugar cane to San Domingo and early in the 16th century it was distributed through-

out the West Indies and South America. It said that Charles V of Spain raised his funds for the construction of his palaces at Madrid and Toledo by import duties levied on San Domingo sugar.

The first shipment of sugar to England was in 1318 by Tomasso Loredano, a Venetian merchant, who exchanged it for wool. For many years it was considered an important medicine and it remained a very costly luxury in Europe until the introduction of coffee and tea drinking.

At the present time Cuba is one of the greatest sugar producing countries of the world and in fact it is the greatest industry of the island. It is grown from cuttings and the methods of cultivation are very crude. In some countries it produces seed and in this way new varieties are secured, but in Cuba the winters are severe enough (45 degrees Fahrenheit) to blight the flowers and prevent seeding. The winter of 1905-6 was very mild and a considerable number of seedling plants were grown at the Harvard Experiment Station at Cienfuegos, Cuba.

The growing of sugar cane is usually conducted on a very large scale and often many thousands of acres are under a single management. During the grinding season a very large number of laborers are necessary both in the fields and in the mills. The cane is hauled on enormous ox carts to the little narrow gauge railroads which run to various parts of the plantation and is thence transported to the mills. The mills are wonderfully developed mechanisms for extracting the largest possible amount of sugar in the most economical manner. It is rather strange to see this modern machinery in the mills and the old wooden plows that have been used for the past 300 years or more in the fields. By the present method of grinding the Cuban cane produces from 9 to 12 per cent in crude sugar.

HELIUM NOT LIQUIFIED.

Olszewski subjected this gas to the temperature of solid hydrogen —259.° C. at a pressure of 50 m. m., then increased the pressure to 180 atmospheres and first slowly and again suddenly reduced the pressure to one atmosphere. These experiments were repeated several times without a trace of mist forming, and there was no separation of solid material noticeable. Using the formula of Laplace and Poisson he calculates the boiling point of helium is below —271.° C. or within two degrees of absolute zero.

Whether this gas will ever be liquified or not we cannot tell but it would be as interesting to science to know that helium is a permanent gas as to liquefy it.

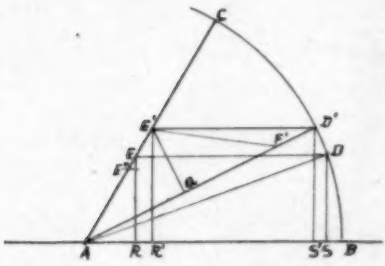
ANOTHER TRISECTION FALLACY.

ROBERT E. MORITZ, PH. D.

The University of Washington, Seattle, Wash.

In the May number of SCHOOL SCIENCE AND MATHEMATICS appeared the following construction for the trisection of any angle less than a right angle.

Let B A C be the angle to be trisected. On A C take a point E′ such that AE′ is less than one half of AC, and the perpendicular from E′ on AB greater than one third of the arc BC. Through E′ draw E′D′ parallel to AB cutting the arc BC in D′ and join D′ to A. On AD′ take F′ so that E′F′ equals E′A. Next take AE″ equal to half the sum of E′F′ and F′D′. Take E″E equal to one third the distance E″E′ and through E draw ED parallel to AB, intersecting the arc BC in D. Then it is asserted that the arc BD equals one third of arc BC.



It should be observed first that the conditions imposed upon the point E′ are not possible for every angle less than 90°. For putting $AC=r$, $AE'=x$, and the radian measure of the angle BAC equal to θ, the imposed conditions assume the form

$$x < \frac{r}{2},\ x \sin\theta > \frac{r\theta}{3},$$

$$\text{that is} \quad \frac{r}{2} > x > \frac{r\theta}{3\sin\theta},$$

$$\text{consequently} \quad \frac{r}{2} > \frac{r\theta}{3\sin\theta}.$$

This inequality reduces to $3\sin\theta > 2\theta$, that is, no point E′ can be found satisfying both the conditions imposed upon it unless $3\sin\theta > 2\theta$, an inequality which is not satisfiied for angles exceeding 85° 50′.

Let us now assume that the angle is less than 85° 40′, so that the conditions of the construction are possible. The construction will lead to different points D depending upon the position of the initially assumed point E. To show this we need only express the angle DAB in terms of the distance AE′.

In the preceding figure, draw E'Q perpendicular to AD', also draw lines from each of the points E, E', D, D' perpendicular to AB.

Put $AB = r$, $AE' = x$, $\angle BAC = \theta$, $\angle BAD' = \phi'$, $\angle BAD = \phi$.

Then $E'F' = x$, $AQ = x\cos(\theta-\phi')$, $F'D' = AD' - 2AQ = r - 2x\cos(\theta-\phi')$, $AE'' = \frac{1}{2}(E'F' + F'D') = \frac{1}{2}[x + r - 2x\cos(\theta-\phi')]$, $AE = AE'' + \frac{1}{3}(AE' - AE'') = \frac{1}{3}(2AE'' + AE') = \frac{1}{3}[2x + r - 2x\cos(\theta-\phi')]$, $ER = AE\sin\theta$, $\sin\phi = \frac{ER}{AD} = \frac{\sin\theta}{r}\cdot\frac{1}{3}[2x + r - 2x\cos(\theta-\phi')]$.

Now, $\sin\phi' = \frac{D'S'}{AD'} = \frac{E'R'}{r} = \frac{x}{r}\sin\theta$, $\cos\phi' = \sqrt{1-\sin^2\phi'} = \frac{1}{r}\sqrt{r^2 - x^2\sin^2\theta}$, hence $\cos(\theta-\phi') = \cos\theta\cos\phi' + \sin\theta\sin\phi' = \frac{1}{r}(\cos\theta\sqrt{r^2 - x^2\sin^2\theta} + x\sin^2\theta)$, and substituting this value in the expression for $\sin\phi$ above, we obtain finally

$$\sin\phi = \frac{\sin\theta}{3r^2}(2rx + r^2 - 2x\cos\theta\sqrt{r^2 - x^2\sin^2\theta - 2x^2\sin^2\theta}).$$

The last result shows that ϕ depends not only upon θ, the angle to be trisected, but also upon x, the distance of the point E' from A.

For example, if the angle to be trisected is 48°, the construction may yield as large an angle as 16° 2', when $x = 0.3709\,r$, or as small an angle as 14° 25', when $x = 0.9348\,r$. These are extreme values and the corresponding values of x do not satisfy the arbitrary conditions imposed upon it in the construction. But if x is taken equal to $0.49\,r$, the conditions are satisfied, and the construction yields 15° 52' instead of 16°.

To sum up: The construction imposes two conditions upon a point which cannot always be satisfied. When the conditions imposed are satisfied, the construction does not trisect the angle. Nor does the result always give a good approximation as is shown in the example given.

PROBLEM DEPARTMENT.

PROFESSOR IRA M. DELONG,
University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

22. *Proposed by E. B. Escott, M. A., Ann Arbor, Mich.*

If ω is any complex root of $x^{13} - 1 = 0$, show that $\omega + \omega^3 + \omega^4 + \omega^9 + \omega^{10} + \omega^{12}$ and $\omega^2 + \omega^5 + \omega^6 + \omega^7 + \omega^8 + \omega^{11}$ are roots of the equation $x^2 + x - 3 = 0$.

Also show that $\omega + \omega^5 + \omega^8 + \omega^{12}$; $\omega^2 + \omega^3 + \omega^{10} + \omega^{11}$; $\omega^4 + \omega^6 + \omega^7 + \omega^9$ are roots of the equation $x^3 + x^2 - 4x + 1 = 0$.

Solution by proposer.

$x^{13} - 1 = 0$ has one real root 1. If ω be any complex root then the remaining roots are $\omega^2, \omega^3, \ldots . \omega^{12}$. Since the sum of the roots of $x^{13} - 1 = 0$ is zero, $1 + \omega + \omega^2 + \omega^3 + \ldots . + \omega^{12} = 0$

or $\omega + \omega^2 + \omega^3 + \ldots . + \omega^{12} = -1$

Let $\alpha = \omega + \omega^3 + \omega^4 + \omega^9 + \omega^{10} + \omega^{12}$

$\beta = \omega^2 + \omega^5 + \omega^6 + \omega^7 + \omega^8 + \omega^{11}$

Then $\alpha + \beta = -1$, $\alpha\beta = -3$ (remembering that $\omega^{13} = 1$ and therefore if n is > 13, $\omega^n = \omega^{n-13}$.) Then α and β are roots of equation $x^2 + x - 3 = 0$. Similarly for the other equation.

Also solved by I. L. Winckler, E. L. Brown, Albertus Darnell.

A correct solution of Algebra 17 was received from Rachael E. Meritzer too late for crediting in the June number.

GEOMETRY.

14. *Proposed by W. D. Higdon, St. Louis, Mo.*

If the bisectors of two angles of a triangle are equal the triangle is isosceles. (Preferred, a direct geometrical proof.)

[A considerable body of literature has grown up on this problem. Solutions are given in the *Analyst*, vol. 1, page 66; the *School Visitor*, vol. 13, page 125, and in Halsted's *Elementary Synthetic Geometry*, pages 44-45. Mr. E. L. Brown sends us a reference to the *American Mathematical Monthly*, vol. 5, No. 4. In volume 7, page 226 of the *Monthly* this problem is discussed again and it is stated that it had been solved eight times previously. In the *Annals of Mathematics*, vol. 4, page 22, Dr. H. C. Blichfeldt solves the more general proposition: "In a triangle ABC, straight lines AD and BE are drawn, intersecting the sides BC and AC respectively in the points D and E, and dividing the angles CAB and CBA internally in the same ratio, so that angle CAD: angle DAB = angle CBE: angle EBA; then if BE and AD are equal, the triangle ABC is isosceles." The remarkable thing about Dr. Blichfeldt's proof is that it does not depend upon parallel

lines, nor on the angle-sum of a triangle being any given amount, and it is therefore valid in non-Euclidean as well as in Euclidean space. No direct solutions have been received.—EDITOR.]

I. *Solution by Ralph E. Root, Sc.B., Forest City, Ia.*

Let ABC be the triangle with the equal bisectors AD and BE intersecting at O.

Now AC is greater, equal to, or less than BC.

Assume AC > BC, then angle ABC > angle BAC and consequently angle OBA > angle OAB, and OA > OB.

Through B draw a line cutting OD at F, and making angle OBF = angle OAE.

Since angle OBF < angle OBD, F falls between O and D. Triangles OAE and OBF are similar, therefore,

$$\frac{OE}{OA}=\frac{OF}{OB}, \text{ then } \frac{OA-OE}{OA}=\frac{OB-OF}{OB},$$

and as OA > OB, OA − OE > OB −OF, or OA + OF > OB + OE. But AD > OA + OF, and OB + OE = BE, therefore AD > BE.

But this is contrary to hypothesis, therefore the assumption is not valid.

Similarly the assumption that AC < BC leads to the conclusion that AD < BE, and is therefore not valid.

Consequently AC = BC, and the triangle is isosceles.

II. *Solution by J. Alexander Clarke, A.M., Philadelphia, Pa.*

Let ABC be the triangle, the bisectors AD, BC being equal. From O, the intersection of AD, BE draw OM, ON perpendicular to BC, AC. OM =ON.

Suppose angle A greater than angle B.

$$\therefore \begin{array}{l} OB>OA \\ OD>OE \\ BD>AE, \end{array}$$

the latter inequality resulting from a comparison of triangles ABD, ABE. Since these three inequalities are incompatible with the equation OM = ON between the altitudes ,the assumption that angle A is greater than angle B is inadmissible. Similarly A cannot be less than B, and therefore the triangle is isosceles.

Analytical solutions were received from E. L. Brown and W. H. Hays. Three incorrect solutions were received.

23. *Proposed by L. B. U., Boston, Mass.*

Through A, the point of intersection of two circles, draw any secant intersecting the circles again in M and N. Prove that the tangents to the circles at M and N intersect in a constant angle.

I. *Solution by I. L. Winckler, Cleveland, Ohio.*

Let B be the other point of intersection of the two circles; draw AB. Let tangents intersect at P. Angle BAM is measured by ½ arc BM and angle BAN is measured by ½ arc BN

Since BAM + BAN = 2 right angles,
arc BM + arc BN is constant and
∴ arc AM + arc AN is constant and
angle M + angle N is constant. Hence angle P is constant.

II. *Solution by E. L. Brown, M.A., Denver, Colo.*

Let the tangents at M and N intersect at T. Draw tangents to each of the circles at A, intersecting MT and NT at B and C respectively.

MTN + TMN + TNM = 180° = BAC + BAM + CAN

But TMN = BAM ,and TNM = CAN

∴MTN = BAC, an angle that remains constant under the conditions of the problem.

Also solved by T. M. Blakslee.

24. *Proposed by R. C. Shellenbarger, Yankton, S. D.*

Inscribe a square within the part common to two intersecting circles.

No correct solution has been received.

TRIGONOMETRY.

25. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

The sides of a triangle are in arithmetic progression with a common difference of one; the greatest angle is double the least. Solve the triangle.

Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

Let A = x, C = $2x$, the exterior angle at B = $3x$. Also, let a = y; b = $y + 1$, c = $y + 2$.

I. By law of Sines.

$$\frac{y+1}{y} = \frac{\sin 3x}{\sin x} = 4\cos^2 x - 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{y+2}{y} = \frac{\sin 2x}{\sin x} = 2\cos x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

By means of (1) and (2) $y^3 - 3y = 4$, whence, if y is finite and positive, its value is 4.

Therefore the sides and angles are respectively 4, 5, 6; 41° 24′ 34″.6, 55° 46′ 16″.2, 82° 49′ 9″.2.

II. By Areas. $y\,(y+2)\sin 3x = (y+1)\,(y+2)\sin x$

$(y+1)\,(y+2)\sin x = (y+1)\,y\sin 2x$

and the solution is completed as in I.

III. By Half-Angle Laws.

$$s = \frac{3+3y}{2},\ s-a = \frac{y+3}{2},\ s-b = \frac{y+1}{2};\ s-c = \frac{y-1}{2}$$

$$\text{Hence, } \sin\frac{x}{2} = \tfrac{1}{2}\sqrt{\frac{y-1}{y+2}},\ \cos\frac{x}{2} = \tfrac{1}{2}\sqrt{\frac{3(y+3)}{y+2}}$$

$$\sin\frac{c}{2} = \sin x = \tfrac{1}{2}\sqrt{\frac{y+3}{y}}$$

Therefore $2y^3 - y^2 - 25y - 12 = 0$, and the only positive value of y is $y = 4$.

IV. By Law of Cosines.

$y^2 = (y + 1)^2 + (y + 2)^2 - 2\ (y + 1)\ (y + 2)\ \cos x$

$(y + 2)^2 = y^2 + (y+ 1)^2 - 2y\ (y + 1)\ \cos 2x,$

and since $\cos 2x = 2\cos^2 x - 1,$

$2y^3 - y^2 - 25y - 12 = 0,$

and the solution proceeds as in III.

Also solved by O. R. Sheldon, Harry Bouchard, I. L. Winckler, E. L. Brown, W. J. Risley, J. L. Riley.

26. ***Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.***

A steeple of a church rises 100 feet above the base of the steeple. Two persons are at horizontal distances of 200 feet and 300 feet respectively from the steeple, the steeple appearing to them under the same vertical angle. What is the distance from the ground to the base of the steeple?

Solution by E. L. Brown, M.A., Denver, Colo.

Let AB be distance from ground to base of steeple, BC the steeple, D and E the two persons whose distances from the steeple are 200 feet and 300 feet respectively.

Since angles CEB and CDB are equal, the points E, D, B, C are cyclic.

Therefore, AB (AB + 100) = 60,000

and AB = 200 or − 300.

Also solved by I. L. Winckler, Harry Bouchard.

PROBLEMS FOR SOLUTION.

ALGEBRA.

32. ***Proposed by I. L. Winckler, Cleveland, Ohio.***

A man has a debt of $4,000 and agrees to pay it in four equal installments, interest at 5 per cent per annum, compounded every instant. Required the annual payment.

33. ***Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.***

A man has a tract of land containing a acres; part of this tract he sold for b dollars per acre more than the rest and he realized c dollars on each portion. What price per acre did each portion sell for and how many acres in each part?

GEOMETRY.

34. ***Proposed by J. Alexander Clarke, A.M., Philadelphia, Pa.***

Find a point from which two given lines (or line-segments) are seen at the same angle.

35. ***Proposed by J. L. Brown.***

ABC is a triangle right-angled at C; M, N, R squares on the sides AC, CB, BA; PS and TK are lines joining adjacent vertices of N, R and M, R. Prove that the common chord of the two circles on Ps and TK as diameters passes through C and the mid-point of KS.

LEADING ARTICLES IN SOME CURRENT MAGAZINES.

The August *Popular Science Monthly* contains among other excellent articles the following: "The Investigation of the San Francisco Earthquake," G. K. Gilbert; "Seismograph and Magnetograph Records of the San Francisco Earthquake," Dr. L. A. Bauer; "Reminiscences of Yukon Exploration," William Healey Dall; "Fact and Fable in Animal Psychology," Professor Joseph Jastrow; "The Measure of Progess," Dr. Edward S. Holden; "The Study of Variable Stars," Professor Solon I. Bailey.

In *Science* of July 6 are found: "A Sketch of the Development of the Rockefeller Institute for Medical Research," Dr. L. Emmett Holt; "The Endowment of Research," Dr. William H. Welch. July 13: "The Use of Astronomical Telescope in Determining the Speed of Migrating Birds," Dr. Joel Stebbins, Edward A. Fath; "A Workable Bed of Coal in Nebraska," Erwin H. Barbour. July 20: "The Aims of an Astronomer," Professor Edward C. Pickering. July 27: "Technical Education in Relation to Industrial Development," Charles G. Washburn.

The *Scientific American* in its issue of July 21 contains an interesting article on: "Industrial Alcohol: How it is Made and How it is Used."

In the July *Physical Review* the following articles are noticed: "The Reflection of Cathode Rays from Thin Metallic Films," S. R. Williams; "On the Physical Properties of Fused Magnesium Oxide," H. M. Goodwin and R. D. Mailey; "Distributions of Colloidal Nuclei and of Ions in Dust-Free Carbon Dioxide," C. Barus; "Studies in Luminescence—Further Experiments on the Decay of Phosphorescence in Sidot Blende and certain other Substances," Edward L. Nichols and Ernest Merritt; "An Inductance and Capacity Bridge," A. De Forest Palmer, Jr.

The *Technical World Magazine* in its July issue has the following: "Street Railways Which Repair Themselves," by Henry Hale; "On the World's Last Frontier," by Richard A. Haste.

In the *Scientific American* supplement for July 7 is an article on "Alcohol from Sawdust" and another on the "Economic Value of New Game for Islands," by Judge D. W. Prowse. In the issue of July 14 we find one on "Flowers that Feel," by Joseph H. Painter.

Review of Reviews for July contains: "The Awakening of Nevada" (illustrated); "The Decrease in Rural Population," with chart, by W. S. Rossiter.

The *Condor* for July-August, "The Barn Owl and its Economic Value" (illustrated).

DEPARTMENT OF METROLOGY. NOTES.

A Simple Metric Chart. With this issue a new and much simplified metric chart is presented to the readers of SCHOOL SCIENCE AND MATHEMATICS. It is simpler than any similar chart ever issued, but it contains the entire essence and cannot fail to appeal to everybody who has ever studied that conglomeration of weights, volumes and measures we call our customary English system.

Attention is called to the fact that the figures are not perspective drawings but isometric projections so that each side in the representation of the cubes measures an exact decimeter or centimeter.

Copies of this metric chart ought to be in the hands of every school pupil old enough to study arithmetic. Its expense is the bare cost of paper, printing, and postage. A duplicate copper plate can be had for $2.00. Such a chart teaches at a glance more of the metric system than a mere description hours in length.

Our readers are indebted for the chart to Frederick Brooks, C.E., Boston, Mass., who is probably the best authority in this country on the metric system. The original features were conceived and the plate designed and paid for by Mr. Brooks. Many years ago he designed the larger metric chart issued by the American Metrological Society, and is author of numerous articles on different phases of the subject, as far back as the seventies, besides being a considerable contributor to our magazine.

R. P. W.

DISCUSSION OF THE NEW MOVEMENT AMONG PHYSICS TEACHERS.

In response to a request for suggestions as to the best way of directing the New Movement, the joint committees have received the following letter from Prof. E. H. Hall of Harvard. Because of the interest and importance of the points raised, Professor Hall's consent to print the letter has been secured. We hope that those who have success with the experiments questioned will send answers to the queries, thereby contributing their share to the discussion:

In answer to your letter of June 1 relative to "A New Movement Among Physics Teachers" I will say that I have watched this movement with interest and believe that good is likely to come of it. Twenty years ago, when the "Harvard System" to which you refer was in its beginning, it seemed to be necessary for some college man or men to take the lead and lay out a very definite course of work as a guide for school men; for at that time there were comparatively few school teachers of physics who had made any considerable amount of special preparation for the teaching of that science. To-day, partly, I think, through the influence which the "Harvard System," with all its faults, has exerted, there are very many teachers in the schools of this country whose opinions concerning the proper range and the best method of physics teaching in schools are mature and weighty.

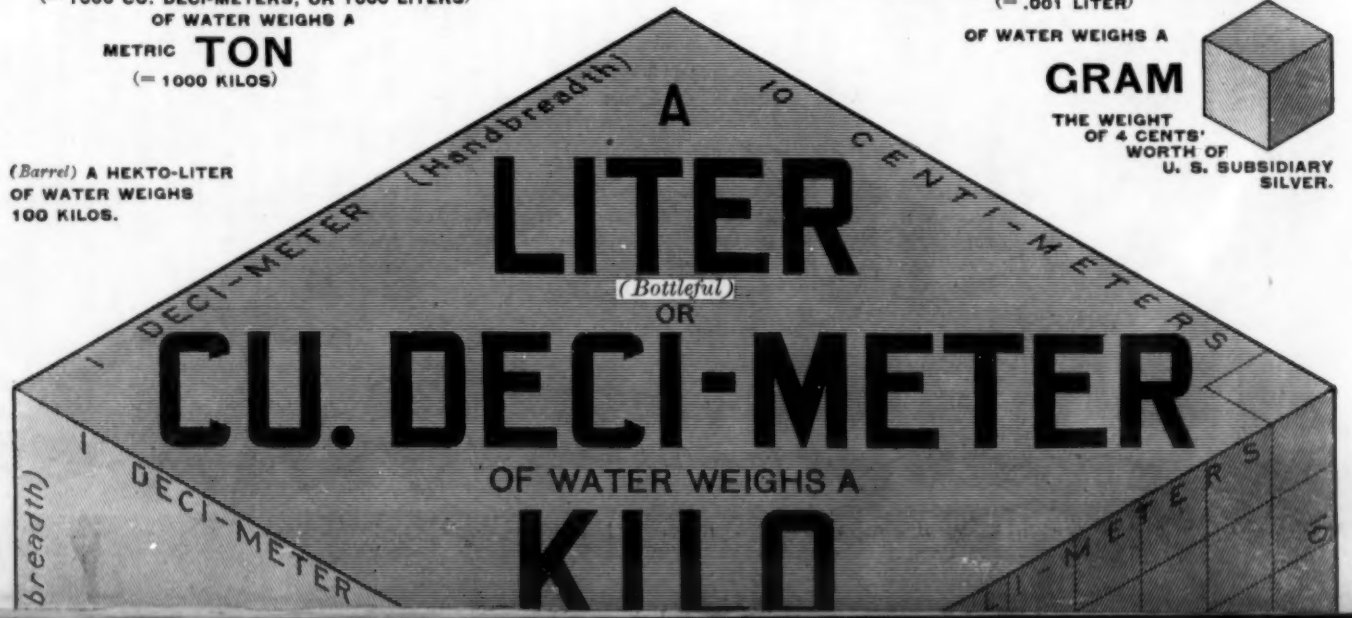
METRIC SYSTEM

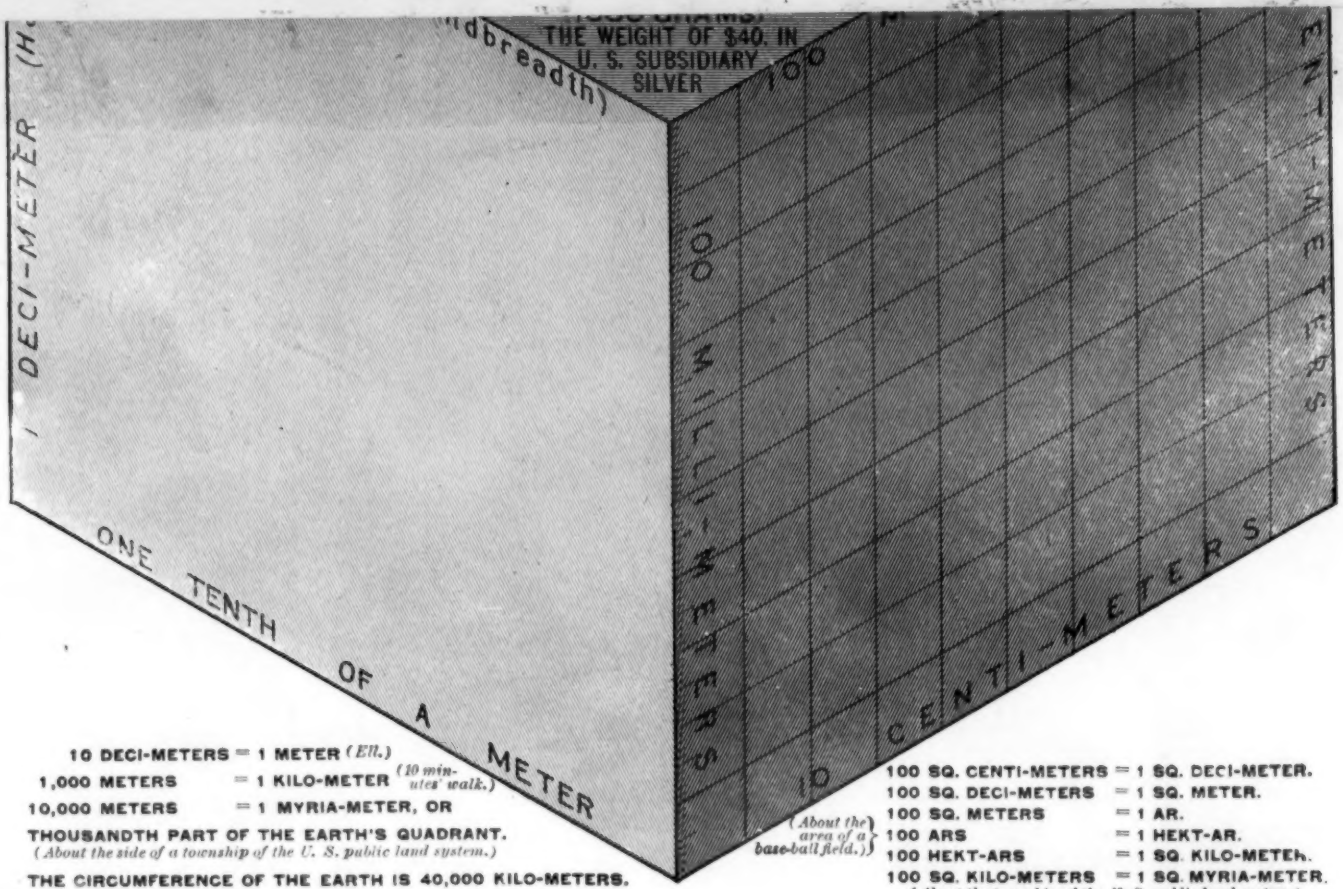
IN USE BY ALL NATIONS.

(*Tun*) **A CUBIC METER**
(= 1000 CU. DECI-METERS, OR 1000 LITERS)
OF WATER WEIGHS A
METRIC **TON**
(= 1000 KILOS)

(*Barrel*) A HEKTO-LITER
OF WATER WEIGHS
100 KILOS.

A CUBIC CENTI-METER
(= .001 LITER)
OF WATER WEIGHS A
GRAM
THE WEIGHT
OF 4 CENTS'
WORTH OF
U. S. SUBSIDIARY
SILVER.





10 DECI-METERS = 1 METER (*Ell.*)
1,000 METERS = 1 KILO-METER (*10 minutes' walk.*)
10,000 METERS = 1 MYRIA-METER, OR
THOUSANDTH PART OF THE EARTH'S QUADRANT.
(*About the side of a township of the U. S. public land system.*)

THE CIRCUMFERENCE OF THE EARTH IS 40,000 KILO-METERS.

(*About the area of a base-ball field.*)

100 SQ. CENTI-METERS = 1 SQ. DECI-METER.
100 SQ. DECI-METERS = 1 SQ. METER.
100 SQ. METERS = 1 AR.
100 ARS = 1 HEKT-AR.
100 HEKT-ARS = 1 SQ. KILO-METER.
100 SQ. KILO-METERS = 1 SQ. MYRIA-METER.
(*About the township of the U. S. public land system.*)

I have no fear of the final outcome of an appeal to the judgment of these teachers, though I do not expect that judgment to agree in all particulars with what mine has been. Accordingly I am glad to see a movement which calls for definite propositions for the improvement of present conditions and methods of instruction; this is so much better than the somewhat vague and ranting criticism of these conditions and methods which we occasionally see and hear.

And yet I should like to offer a friendly challenge to some of these propositions. Looking over your list of forty-seven exercises which are approved by a majority of the answers you received I find twelve, and only twelve, which do not appear by title or under a like title in the National Educational Association list. These twelve are the *inclined plane, pulleys, pendulum, barometer, boiling-point and pressure, phenomena of electrostatics, phenomena of magnetism, magnetic field with filings, D'Arsonval galvanometer, induced currents, electromagnet, electric bell.*

Immediately preceding the *inclined plane* in your list is *three forces in a plane;* that is, the *parallelogram of forces.* Now what is the use of the parallelogram of forces if it does not enable us to foretell, barring friction, the action of the inclined plane? Is it not enough to show the inclined plane on the lecture table, point out its relation to the preceding laboratory exercise and then try one or two simple cases of its use, calculating in advance (with the coöperation of the class) the conditions for equilibrium? After this, if the subject demands more time, will not simple numerical problems on the inclined plane be more profitable than a set laboratory exercise? Is not a laboratory exercise on the coefficient of friction, with use of the inclined plane, better than one on the apparatus itself, after the parallelogram of forces?

As to *pulleys*, I question the need of a laboratory exercise on them, if the principles of levers have been mastered. Simple combinations of pulleys are easily understood, after the lever. Complicated combinations introduce so much friction that they are objectionable. It is true that many boys like to play with such combinations. Very well, show the apparatus on the lecture table, discuss it from the point of view of the lever, then at the next laboratory exercise give the pupils a few minutes to lay their hands on it and pull the strings. They will not need or care to work at it long.

To save much repetition I will say here that this device, of giving a few minutes at the beginning or the end of a quantitative laboratory exercise for the boy to see and try various interesting pieces of apparatus in a qualitative way, seems to me a very effective way of meeting that demand of which President G. Stanley Hall makes so much, for seeing the "go" of things. To keep a young class profitably, or even agreeably, occupied in this way through a whole laboratory exercise is a very different undertaking.

The laws of *the pendulum* certainly furnish grounds for a clean cut and available laboratory exercise. I am not in the habit of giving this exercise to beginners in physics, partly because it does not seem

to me to lead very far without more knowledge of dynamics than schoolboys or college freshmen can be expected to master, partly because I found long ago that the law of length can be shown to great advantage at the lecture table by starting simultaneously two simple pendulums whose lengths bear to each other the ratio four to nine or nine to thirty-six. The aplumb with which the two pendulums of different periods of vibration come together, for an instant, at stated intervals, though performing the most discordant evolutions beween times, always delights a class.

The *barometer*, in your list as printed, follows *Boyle's law*. But how can one take up Boyle's law without the barometer and how can one make a laboratory exercise out of the study of the barometer alone without taking up such refinements as reading by use of the vernier and correcting for expansion of mercury and brass, details which are quite beyond the needs of the young student in his use of the barometer? It seems to me that the reading of the barometer should be introduced as a part of the exercise on Boyle's law.

How extensive should the exercise on *boiling point and pressure* be? If it is to range far enough to show plainly the character of the vapor pressure curve as plotted on the pressure-temperature plane, from 20 cm. pressure to 100 cm. pressure, let us say, or even half that distance, it is quite enough for a separate laboratory exercise, a very instructive one. But such an exercise, according to my experience, is a rather troublesome one, requiring strong and air-tight apparatus. If, on the other hand, we intend to show merely that, in the neighborhood of the ordinary boiling point, a rise of one degree in temperature corresponds to a rise of about 3 cm. in pressure, this comes in readily enough and very appropriately in connection with the *testing a thermometer*.

In *phenomena of electrostatics*, *phenomena of magnetism* and *magnetic field with filings* we have a group of three qualitative exercises. There is certainly a fascination for pupils and teachers in the phenomena here indicated. Moreover, the number of answers reporting *success* with these exercises would seem to prove that they have been brought into practicable shape for class use. I wish that some of those who have had this success with the *phenomena of electrostatics*, for example, would describe their method. Does it consist mainly of making a table of various substances, fur, flannel, silk, glass, etc., in their electrostatic order? If not, how is the thing managed? My own practice with electrostatics for beginners is to show many of the phenomena in lectures and then expose some of the apparatus, catskin and gutta percha, a metal-leaf electroscope of an unfragile sort, an electrophorus, a small Voss induction machine, etc., in the laboratory for the voluntary use of such students as may choose to handle them. Naturally, I do not expect my class to be prepared for any very searching examination in electrostatics.

Is there need of two qualitative exercises in simple magnetism? Cannot the *magnetic field with filings* be combined to advantage with the *phenomena*?

As to the other new titles in the list, *D'Arsonval galvanometer, induced currents, electromagnet, electric bell*, I do not feel sufficiently sure as to how much each one signifies in the way of a laboratory exercise to justify my commenting on them favorably or unfavorably.

Having criticised many of the new titles I will now find fault with one of the old ones. I wish that *resistance by substitution* could be dropped from the list. With the inexpensive Wheatstone bridges and sensitive galvanometers which are now available there is little further use, it seems to me, for this exercise. I think, too, that it is well to replace the laboratory exercise on *weight of water displaced* (by a floating body) by a lecture table experiment like the following: Put an overflow vessel filled to the critical point on one pan of a platform balance and counterpoise it with weights. Place carefully in this vessel a suitable floating body and let the overflow occur. As the flow ceases the balance returns to a state of equilibrium, showing that the weight of the water which has run out is equal to the weight of the floating body. This brings out the fact which we are after in a striking way. An hour's work in the laboratory could hardly make the matter plainer; and the list of exercises contains so many relating to specific gravity and the principles of flotation that this one exercise is scarcely to be justified on the ground of the practice which it gives in manipulation.

I note the absence from your list of all experiments on friction, and this raises an interesting question which I discussed very recently with an experienced school teacher of physics. He considered experiments on friction as very troublesome and unsatisfactory, because of the difficulty which the pupil finds in making up his mind just what conclusions to draw from his observations. Troublesome such experiments certainly are; but should we avoid all troublesome experiments or all experiments in which the pupil's own observations leave him somewhat in doubt? Is there not some danger that we shall get into the way of making the laboratory exercises too definite and mechanical? If the pupil is told in advance that the so-called laws of friction between solids are not absolutely rigid, though near enough to the truth to be of great use, is it an unreasonable or an overdiscouraging task to require him to form his own opinion as to whether, in a particular case which he studies, the friction of a block on its broad side is greater or less than the friction of the same block on its narrow side, with the understanding that his opinion is to be taken with the opinions of his classmates in drawing a general conclusion? Are we not, even in so exact a science as physics, frequently obliged to balance probabilities and be content with a conclusion which lacks something of finality?

But I am making this letter too long. If you are willing to send it to some one of the school journals for publication, as a contribution to the important discussion which you are conducting, I shall be glad to have you do so.

Very truly yours,

EDWIN H. HALL.

REPORTS OF MEETINGS.

CONNECTICUT SCIENCE TEACHERS' ASSOCIATION.

This association was formed in the spring, much interest being developed at the time. The following officers were elected:

President, Mr. M. M. Marble, High School, New Haven; Secretary-Treasurer, Miss Caroline J. Hitchcock, High School, Meriden. Executive Committee, Miss Emma F. Eames, High School, Bridgeport; Mr. Clement C. Hyde, High School, Hartford; Mr. Allen Latham, Free Academy, Norwich.

Meetings are to be held in connection with the meeting of the State Teachers' Association in October, and of the Connecticut Association of Classical and High School Teachers in February.

Any person teaching science in the state is eligible to active membership, principals and others interested to associate membership.

CAROLINE J. HITCHCOCK,
Secretary and Treasurer.

June 2, 1906.

NATURAL SCIENCE ASSOCIATION OF ONTARIO.

The annual meeting of the Natural Science Association took place in Toronto on April 17 and 18, in connection with the forty-fifth annual meeting of the Ontario Educational Association.

In addition to interesting addresses by the president and honorary president dealing with practical aspects of science teaching, there were several illustrated lectures, and a valuable conference on "The Teaching of Elementary Science," led by Mr. T. J. Ivey, M.A., of Jarvis Street Collegiate Institute, Toronto. Mr. A. B. Klugh of Guelph, an enthusiastic materialist, gave a highly interesting account of "Bird Migration at Point Pelee." The speaker spent some weeks at Point Pelee in making observations and was able to illustrate his admirable address with specimens and field notes. Dr. W. L. Goodwin of Queen's University, Kingston, gave an historical sketch of the early years of the development of the science of chemistry. He showed the growth of chemical theory up to the present and made clear the fact that the atomic hypothesis is not essential to the teaching of chemistry.

Dr. W. R. Lang of the University of Toronto, addressed a joint meeting of the Mathematical and Physical and the Natural Science Associations, on the subject of Combustion. The experimental features of this lecture were much appreciated.

COLORADO STATE SCIENCE TEACHERS CONFERENCE.

A meeting of the science teachers of Colorado was held in connection with the state teachers association at the University of Colorado, Boulder, May 4 and 5. There was a large attendance and unusually interesting meetings were held. The following program was presented:

Friday.—3 P. M., Room 25 Hale Building, "The necessity for science conferences in Colorado," G. L. Cannon; "The collecting of mollusks in Colorado," Junius Henderson; "The fossil beds of Florissant," T. D. A. Cockerell; "The crustaceans of Colorado," A. E. Beardsley; Reports from the scientific societies of Colorado; 8 P. M., university chapel, main building, address, "The response of plants," Thomas H. Macbride, University of Iowa; reception by President and Mrs. Baker.

Saturday.—9:30 A. M., physical laboratory, Hale Building, "Apparatus illustrating the laws of electromagnetic induction" (with demonstrations), H. E. Sovereign; "A study of blood pressure in man," Edward C. Schneider; "Earthquakes" (with lantern slide illustrations), R. D. George; "A report on the quantitative analysis of uranium and vanadium," A. N. Finn; "A study of the Kater pendulum," J. Arthur Birchley; "New kinds of radiation" (with demonstrations), Wm. Duane; 2 P. M., Room 25, Hale Building, "The projection microscope for work in botany and zoology" (with demonstrations), G. S. Dodds; "The effect of bile on the surface tension of water," W. D. Engle; "Recent geological correlation work in the Canon City field," George I. Finley; "A study of chlorophyll," Ira E. Cutler; "A review of the development of the modern kinetic theory of gases as a basis for the study of radioactivity," Philip Fitch; "Producer-gas and producer-gas engines," F. L. Abbott; "A report on the formation of malic acid by fermentation," J. Vincent Daniels. The laboratories and museums of the university were thrown open for inspection during the noon recess.

CENTRAL IOWA SCIENCE AND MATHEMATICS TEACHERS.

An interesting and helpful meeting of the Central Iowa Science and Mathematics Teachers was held at Des Moines, May 4 and 5. The following program was carried out:

Friday.—7:30 P. M., Inspection of laboratories and equipment of North High School; 8:15 P. M., General meeting in the assembly room, North High School: 1. Music, North High School orchestra; 2. Address of welcome, Superintendent W. O. Riddell, West Des Moines schools; 3. The Central Association of Science and Mathematics Teachers discussion; 4. Organization; 5. Address, "A science in the making" (illustrated), Professor W. S. Hendrixson, Iowa College, Grinnell; 6. Informal reception.

Saturday.—9 A. M., Inspection of laboratories and equipment of West High School; 10 A. M., Section meetings: Science section, natural science lecture room: 1. "The use of the lantern in science work," Miss Grace Troutner, North Des Moines High School; general discussion, led by Professor L. S. Ross, Drake University; 2. "Problems of field work in natural science," Miss Edith Kiefer, East Des Moines High School; general discussion, led by Miss Zulema Kostomlatsky, West High School; 3. "Laboratory experiments in physics," Professor D. W. Morehouse, Drake University; general discussion, led by Lafayette Higgins, West High School; 4. General discussion on new books in science; 5. Round table on problems in science teaching—those present were

requested to hand in topics for such discussion as time would permit, Mathematics section: 1. "Limitations in mathematics," Principal W. A. Crusinberry, West High School; discussion; 2. "Rational geometry," Miss Blanche Pinkerton, Valley Junction; discussion; 3. "The relation of physics and mathematics," Professor L. B. White, Des Moines College; discussion; 4. Round table on problems in teaching of mathematics, led by Professor W. A. Crusinberry, West High School.

NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The association held the second meeting of the year on the evening of April 27 at the Board of Education Building. Principal Felter of the Girls' High School, was the first speaker on the subject of the evening, "The Scope and Value of First Year Biology." Dr. Felter expressed the following views: There was strong opposition at first against first year biology but the interest shown in the subject by the pupils had proved its place and value. The power of observation gained by the study cannot be transferred to other studies, but, even so, the time is well spent. The training in power of expression and accuracy of description, and in use of the pencil will be of value in after walks of life. If biology amounts to anything it amounts to this, that the pupils get certain facts and with them, the power to compare and classify.

Principal Wight, of the Wadleigh High School, the next speaker, objected to the present work in biology as an attempt to do a little of each of too many things, in other words, violating the well approved pedagogical rule, *non multa sed multum*. As a substitute for our present tri-formed biology (botany, zoology, and physiology), let us have botany only, or botany with a modicum of zoology, leaving the hygiene to the department of physical training. The result of such a change should be, instead of an indefinite smattering of three subjects, a definite amount of scholarship in one subject seriously pursued.

Principal Gunnison of Erasmus Hall High School, said in part: I was and am still opposed to biology in the first year of the course. I have given time and thought to the subject and in spite of a most friendly spirit, I have come to feel that we are not doing the right kind of work in biology. There is no place where teachers are doing better work and no place where schools are better equipped but there is something wrong with biology. If it is to be a real scientific course it should be in the senior year. If it is to be mere observation it should be in the grammar schools. If primary schools could have our equipment, great interest might be aroused in the subject. and if it were to be an elective higher up in the course, good work might be done, but with the great mob of first year pupils it cannot be well taught. As a subject in itself, there is nothing more interesting, but as a first year study it is out of place. Biology is a subject different from all others, one in which it is impossible to examine pupils with any satisfaction. Let us put out of our minds all thoughts of an examination and try primarily to interest the pupil.

Principal Denbigh of the Morris High School spoke as follows: It would be difficult to prevent a too elementary grade of work in biology. If we accept Dr. Butler's definition of education—as fitting man to enter into his intellectual inheritance—we greatly wrong a pupil if we leave him unfitted to enter into the great inheritance of scientific truth obtained by past and present research. The problem before us is, what sort of training will best fit the pupil for the enjoyment and right use of life. In striving to work out this problem let us, first, inculcate a habit of scientific thinking, second, give as wide a knowledge as possible, and, third, awaken an interest which shall be lasting.

There should not be too much insistence upon structure as structure or too careful drawings of things seen under the microscope but let us insist that pupils shall make their own observations from well selected specimens of common forms. Train the pupil also to trace likenesses and differences. Interest may be aroused and knowledge best obtained by taking pupils out into the fields and woods, but, if this is not possible, bring the plants and animals into the school. There are reasons why biology might be omitted from "vocational" courses, but no other study would be more helpful in a "cultural" course. The following are two of the many reasons why this is true—the permanence of the interest aroused, and, the scientific habit of thinking. A first year pupil can be made to express himself clearly and effectively and, if the teacher is doing good work, he will be brought up constantly against cause and effect. If the ultimate test of the value of knowledge be that that man may be able to live more rightly we need not doubt the value of our work with first year pupils.

A short discussion followed the regular program of the meeting. Dr. Felter, Dr. Gunnison, and Dr. Wight state that the second year elective was crowded out in their respective schools for lack of laboratory and class room.

MYRA S. CHATTERTON, *Secretary.*

BOOK REVIEWS.

Outdoor Gymnastic Apparatus Catalogue of A. G. Spalding & Bros., Chicago and New York.

This is a handsomely illustrated catalogue and price list of outdoor gymnasium and playground apparatus together with a descriptive list of Spalding's Athletic Library.

Minerals and How They Occur. By Willet G. Miller, provincial geologist of Ontario. The Copp Clark Company, Toronto. pp. v+252; 1906, $1.00.

This is a book just issued to meet the needs of students in secondary schools and of prospectors. Part I consists of a brief outline of geology to serve as an introduction to the main portion of the book. Part II deals with the characters of minerals, and contains excellent tables for rapid determination of a good number of the more common minerals. Part III deals in a highly satisfactory way with rocks and

rock structures. The economic notes of Part IV are valuable in affording one an accurate and comprehensive view of the uses of minerals.

The press work is good and most of the numerous cuts very well illustrate the points made by the writer.

The book cannot fail to have a highly beneficial influence on the study of mineralogy. E. L. H.

Webster's New Standard Dictionary of the English Language. Intermediate School Edition. Laird & Lee, Chicago, 1906. pp. 456; price, 50 cents.

This is the latest volume added to Laird & Lee's excellent series of Webster's New Standard Dictionaries. It contains 30,000 vocabulary words in bold, black type. A few of the most valuable features are the giving of over five thousand synonyms, in italic type, arranged in connection with the vocabulary words; proper nouns indicated by capital initials; degrees of adjectives of irregular comparison; plurals of nouns and irregular forms of verbs; six hundred text engravings arranged in direct connection with the words to be illustrated. Many of these engravings represent the latest developments in the mechanical arts, such as the automobile and typesetting machine. Nature study is represented by hundreds of engravings of animal and plant life. A chapter on English word building is well written. Two pages of prefixes, two of suffixes, three of stems, and four of the more common and important abbreviations together with 20 rules for spelling are given. The type used is large and clear. Altogether the finest and best dictionary for the money we have ever examined. C. M. T.

Conversations in Chemistry. By W. Ostwald. Authorized English translation by Elizabeth Catherine Ramsey and Stuart K. Turnbull. 2 vols. New York: Wiley, 1906.

It is a source of great gratification to us that one of the most illustrious masters of Chemistry has been inspired to devote part of his energy to the problem of elementary instruction in science. As the reason for his having done this, Professor Ostwald says in his preface: "Probably the most important problem that the teacher of to-day is called upon to confront is that of arousing and developing the habit of original thinking and independent initiative in the greatest possible number of individuals among the masses of the people." These little volumes give the results of his own investigations in this field of science pedagogy. They are, therefore, an exceedingly valuable contribution toward the solution of the problem; and they should be carefully studied by every science teacher who has an appreciation of the magnitude and the importance of this perplexing educational enigma.

The subject is presented in the form of a dialogue, this being the most vivid style. He was guided in the selection of the order of presentation of the subject matter by historical study, and tells us: "It has been most instructive to me to find by this study a new confirmation of my conclusion formed some twenty years ago, namely, that the

logical development of a science coincides very nearly with its historical development." Other characteristics of this new method of presentation are the laying of great emphasis on the phenomena studied, so that the measuring processes appear less overbearing; also, the constant reminders of the fact that there are regions of science beyond the range of the elementary course, so that the student may not get dogmatic and limited conceptions of the subject and of its scope.

These books seem to me to be the most important practical contribution toward the solution of the science teacher's problems that has yet been made. All instructors in science should study them from the pedagogical point of view, whether they are chemists or not. They furnish another illustration of the well-known fact that the great masters are the proper instructors for the beginners. C. R. MANN.

A First Course in Physics. By Robert Andrews Millikan and Henry Gordon Gale. 18.8x13.8 cm. viii + 488 pp.

In the movement for a revision of the course in physics in secondary schools there is danger that the pendulum will swing to the opposite extreme from that of recent methods. The authors of this book while conforming to the newer ideas relating to physics teaching yet conserve all that is of value in the old methods. They present the subject from the standpoint of the study of phenomena and at the same time strengthen the disciplinary value of the course.

The book is especially strong in its treatment of the practical application of physics. A few illustrations of topics not generally treated in high school texts are: hydraulic elevators, city water supply, the fire engine, the gas engine, the water turbine, the steam turbine, the diving suit, the gas meter, compensated balance wheel in a watch, hay scales, cold storage, the commercial transformer. The treatment of these topics and of many other practical applications of physics is made very clear by means of diagrams. These practical applications in general follow the laboratory and class room study of principles.

The treatment is simplified by presenting groups of phenomena in their relation to a few fundamental principles. For example: Many of the phenomena heretofore presented in an unrelated way as "properties of matter" are grouped under "molecular forces" and "molecular motions." The simple machines are all presented as depending on the principle of work. Newton's first law of motion, inertia, and centrifugal force are grouped together as they should be. Uniformly accelerated motion and falling bodies are treated together, the latter as a particular case of the former. To the pupil who says, "There are too many things to be learned in physics," the teacher who follows the method of this book can say, "No. You have to learn only a few principles but these you must learn thoroughly."

The treatment of surface tension is admirable. In this and some other topics, as the authors state in their preface, "some familiar fictions of physics have been replaced by 'casually conditioning' facts."

The book contains a good selection of problems, not puzzles, that require for their solution a knowledge of the principles treated in the text.

The topics of interference, wireless telegraphy, X-rays, and radioactivity are discussed in a clear and simple manner.

After a careful reading of the book the reviewer believes that everything it contains is well within the capacity of the high school pupil with the possible exception of paragraph 118 on molecular velocities. The slight historical inaccuracy in the discussion of Archimedes' principle is pardonable since the story should be told to add interest to the discussion and a complete statement of the historical status of the story would have required an undue amount of space.

No laboratory experiments are described in the text, this being the function of the laboratory manual, but the class room experiments are suggestive to the teacher and these require only simple apparatus. The authors are issuing a manual which is adequate to the needs of the strongest high schools and yet which leaves the school with the most limited resources absolutely no excuse for inadequate laboratory treatment of the subject.

The writer believes that both books deserve a favorable reception among physics teachers. The fact that they have been tested in manuscript form in a number of secondary schools and work is in their favor. They are a valuable contribution to reform in physics teaching.

E. E. BURNS.

BOOKS RECEIVED.

Notes on the Rocks and Minerals of Michigan. To accompany the loan collection issued by the Michigan College of Mines. 1905. pp. 105.

Webster's New Standard Dictionary. Intermediate School Edition. Cloth. pp. 456. Laird & Lee, 263-65 Wabash Avenue, Chicago. Black silk cloth, plain edges; price, 50 cents.

Laboratory Astronomy, by Robert W. Wilson, professor of astronomy in Harvard University. 8vo., cloth, pp. 189, with diagrams. Price, $1.35. Ginn & Co., Boston.

The Old and the New Magic, by Henry Ridgeley Evans. Illustrated. pp. 348. 1906. The Open Court Publishing Co., Chicago. Price, $1.70.

Nature Study, by Dr. Dearness of London Normal School. Published by the Copp, Clark Co., Toronto, Canada.

Report of the Superintendent of Education for Nova Scotia. 112 pages. April, 1906.

First Course in Physics, by Robert A. Millikan, University of Chicago, and Henry G. Gale, University of Chicago. Published by Ginn & Co., Boston.

AMERICAN BOOK COMPANY.

Milne's Progressive Arithmetics. By William J. Milne, Ph.D., LL.D., President of New York State Normal College, Albany, N. Y. First Book, cloth, 12mo, 288 pages. Price, 35 cents. Second Book, cloth, 12mo, 300 pages. Price, 40 cents. Third Book, cloth, 12mo, 348 pages. Price, 45 cents.

Storm's Im Sonnenschein, and Ein Grünes Blatt. Edited by G. L. Swiggett, M.A., Ph.D., Professor of Modern Languages, University of the South. Cloth, 12mo, 78 pages, with notes and vocabulary. Price, 25 cents.

Dumas. Excursions sur les Bords du Rhin. Edited by Theodore Henckels, Professor of Modern Languages in Middlebury College, Middlebury, Vt. Cloth, 12mo, 176 pages. Price, 40 cents.

Hugo. Hernani. Edited by James D. Bruner, Ph.D., Associate Professor of Romance Languages in the University of North Carolina. Cloth, 12mo, 264 pages. Price, 70 cents.

Dutton's Little Stories of France. By Maude Barrows Dutton, Author of "The World at Work in Field and Pasture." Cloth, 12mo, 176 pages, with illustrations. Price, 40 cents.

Schiller's Wilhelm Tell. Edited by Edwin C. Roedder, Instructor in German, University of Wisconsin. Cloth, 12mo, 352 pages, with notes and vocabulary. Price, 70 cents.

PROPOSED AMENDMENT TO THE CONSTITUTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

That Article IV be so changed as to include a section in Manual Training.*

We call the attention of our readers to the ad. of the Locke Adjustable Table, which will be found in this issue. This is a simple and inexpensive article with a wide range of convenience and usefulness. It can be used with a stand or attached to a chair, table, bed, or almost any article of furniture. It is universally adjustable, with a ball and socket joint, and in other ways. The price is from $3.00 to $5.00, f. o. b. Chicago. A booklet containing twenty-five illustrations will be sent free by the manufacturers, C. E. Locke Mfg. Co., 362 Spruce, Street, Kensett, Ia.

*This proposed amendment was received after the one on page 601 was in print. EDITOR.

THANKSGIVING MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The sixth annual meeting of this association will be held in the University of Chicago buildings on the Friday and Saturday following Thanksgiving Day. The assembly hall, lecture rooms, and laboratories offered by the university for the uses of the association present especially favorable opportunities for an excellent meeting. On the general program, Professor W. M. Davis of Harvard University, Professor John F. Woodhull of Teachers' College, Columbia University, New York, and probably two other gentlemen of similar national reputation will give addresses. The programs of the sections of the association, in addition to the names above mentioned include the names of many college and secondary school people who are interested in the teaching of science and mathematics.

On Friday morning there will be a general meeting at which time two addresses will be given. In the evening of the same day there will be an associational dinner, a general address, and an informal reception. Friday afternoon and part of Saturday morning will be given to sectional meetings, the remainder of Saturday morning being given to a general meeting during which the annual business meeting will occur. Some of the departmental chairman are arranging for excursions to places of interest to the members of their respective departments, these excursions to be made during Saturday afternoon.

Rooms will be provided for such laboratory appliances as teachers may bring for demonstration.

The executive committee expects to mail the printed program to members of the association early in October. Anyone not a member of the association may obtain a program or become a member by communicating with the secretary, Mr. C. M. Turton, 440 Kenwood Terrace, Chicago.

OTIS W. CALDWELL, President, Charleston, Ill.

AMERICAN MATHEMATICAL SOCIETY—SAN FRANCISCO SECTION.

Regular meeting, University of California September 29, 1906.

The tenth regular meeting of this Section will be held on Saturday, September 29, in Room 21, North Hall University of California. There will be a morning and an afternoon session, opening respectively at 11 A. M. and 2 P. M. During the morning session the officers for the ensuing year will be elected. Titles and abstracts of papers in a form suitable for publication should be in the hands of Professor Wilczynski for the use of the Programme Committee not later than Saturday, September 15.

Programme Committee:

E. J. WILCZYNSKI,
D. N. LEHMER,
G. A. MILLER.

Address of Professor Wilczynski: 2337 Telegraph Ave., Berkeley, Cal.